UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

APR 1 8 2006

In response refer to:
151422SWR02SA8279:JSS

James N. Seiber
Director
U.S. Department of Agriculture
Pacific West Area, Western Regional Research Center
Agricultural Research Service
800 Buchanan Street
Albany, California 94710-1105

Dear Mr. Seiber:

This letter transmits NOAA's National Marine Fisheries Service's (NMFS's) biological opinion (Enclosure 1) based on our review of the proposed *Egeria densa* Control Program (EDCP) 1-year extension of treatment in the Sacramento-San Joaquin Delta (Delta) in the State of California, and its effects on Federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened Central Valley steelhead (*O. mykiss*), threatened southern distinct population segment (DPS) of North American green sturgeon (*Acipenser medirostris*), and designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Your September 9, 2005, request for formal consultation was received on September 14, 2005. A response was sent on October 19, 2005, indicating that NMFS would require additional information from the U.S. Department of Agriculture-Agricultural Research Services (USDA-ARS) in order to initiate the consultation process. On October 25, 2005, the USDA-ARS withdrew its request for formal consultation on a new 5-year program, and instead requested a 1-year extension of the 2003 through 2005 EDCP action. NMFS has chosen to reissue the biological opinion in its entirety because in addition to assessing the effects of extending the project through 2006 on listed species and habitat, the critical habitat analyses for Central Valley spring-run Chinook salmon and Central Valley steelhead are new, as is the assessment of effects of the EDCP on North American green sturgeon.

This biological opinion is based in part on information provided from the annual reports for the EDCP from 2003 through 2005; the September 9, 2005, request letter; the previous biological assessment for the 2003 through 2005 action; and the September 28 and November 4, 2005, meetings between staff from NOAA Fisheries, the USDA-ARS, and DBW for the proposed 1-year extension of the 2003 through 2005 EDCP actions. A complete administrative record of this consultation is on file at the Sacramento, California, field office of NOAA Fisheries.

Based on the best available scientific and commercial information, the biological opinion concludes that the EDCP extension for the 2006 application season (1 year), as proposed by the USDA-ARS and DBW, is not likely to jeopardize the continued existence of the listed species or adversely modify designated critical habitat. NMFS also has included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to avoid, minimize, or monitor incidental take associated with the project. The listing of the Southern DPS of North American green sturgeon becomes effective on July 7, 2006, and some or all of the ESA section 9(a) prohibitions against take will become effective upon the future issuance of protective regulations under section 4(d). Because this biological opinion extends only through the 2006 application season, green sturgeon are not discussed in the incidental take statement.

NMFS's Essential Fish Habitat (EFH) conservation recommendations for Pacific salmon (*O. tshawytscha*), starry flounder (*Platichthys stellatus*), and English sole (*Parophrys vetulus*) as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended (16 U.S.C. 1801 *et seq.*) are unchanged from the original issued in conjunction with the biological opinion assessing the effects of the 2003 through 2005 EDCP action, and are attached for your reference (Enclosure 2). This document concludes that the EDCP will adversely affect the EFH of Pacific salmon, starry flounder, and English sole in the action area and adopts certain terms and conditions of the incidental take statement of the biological opinion as the EFH conservation recommendations.

USDA-ARS has a statutory requirement under section 305(b)(4)(B) of the MSA to submit a detailed response in writing to NMFS within 30 days of receipt of these conservation recommendations that includes a description of the measures proposed for avoiding, mitigating, or offsetting the impact of the activity on EFH (50 CFR 600.920 [j]). If unable to complete a final response within 30 days, the USDA-ARS should provide an interim written response within 30 days before submitting its final response.

Please contact Mr. Jeffrey Stuart in our Sacramento Area Office at (916) 930-3607 or via e-mail at J.Stuart@noaa.gov if you have any questions regarding this response or require additional information.

Sincerely,

for Russell M Strach

Rodney R. McInnis
Regional Administrator

Enclosures (2)

cc: NOAA Fisheries-PRD, Long Beach, CA
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Enclosure 1.

BIOLOGICAL OPINION

ACTION AGENCY:	U.S. Department of Agriculture-Agricultural Research Service
ACTIVITY:	*Egeria densa* Control Program 1-Year Extension (2006)
CONSULTATION CONDUCTED BY:	Southwest Region, National Marine Fisheries Service
FILE NUMBER:	151422SWR2002SA8279:JSS

I. CONSULTATION HISTORY

Previous consultations by NOAA's National Marine Fisheries Service (NMFS) addressing the effects of the *Egeria densa* Control Program (EDCP) on listed salmonids resulted in the issuance of biological opinions on July 23, 2001; July 3, 2002; and August 11, 2003. These biological opinions respectively concluded that the EDCP was not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), and Central Valley steelhead (*O. mykiss*), or adversely modify designated critical habitat for the 2001, 2002, and 2003 through 2005 application seasons.

On September 14, 2005, NMFS received the U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS) request for initiation of formal section 7 consultation under the Endangered Species Act (ESA) for the EDCP covering application seasons 2006 through 2010.

On September 28, 2005, a meeting was held at NMFS' Sacramento office between staff from the USDA-ARS, the California Department of Boating and Waterways (DBW) and NMFS to discuss the EDCP consultation and the necessary information to be included in the project's biological assessment (BA). At this meeting it was decided that USDA-ARS and the DBW would request a 1-year extension of the present EDCP.

On October 24, 2005, NMFS received a written request from the USDA-ARS withdrawing the original request for section 7 consultation concerning a new 5-year application period, and instead requesting formal section 7 consultation regarding a 1-year extension of the EDCP via an amendment to the standing biological opinion for application seasons 2003 to 2005. Due to the recent designation of critical habitat for Central Valley spring-run Chinook salmon and Central Valley steelhead, and the recent listing as threatened of the Southern Distinct Population Segment (DPS) of North American green sturgeon (*Ascipenser medirostris*), NMFS decided reissue the biological opinion in its entirety with new critical habitat analyses and an assessment of the effects of the EDCP on green sturgeon.

On November 4, 2005, a second meeting was held at NMFS' Sacramento offices between staff from the aforementioned agencies to discuss the progress of the consultation.

II. DESCRIPTION OF THE PROPOSED ACTION

The USDA-ARS has requested formal section 7 consultation pursuant to the ESA in order to implement an additional year (*i.e.*, 2006) of the EDCP, an aquatic weed control program, within the geographic boundaries of the Sacramento-San Joaquin Delta (Delta). This program will apply different herbicides to the waterways of the Delta to control the non-native invasive plant, *Egeria densa*. The USDA-ARS, in fulfillment of their directive to control and eradicate agricultural pests, has contracted with the DBW to implement the control program and to conduct research activities in association with the EDCP while providing oversight during the program's implementation.

The *Egeria densa* Task Force, led by the USDA-ARS, proposes to chemically control the growth and spread of *Egeria densa* with the aquatic herbicides Reward® and Sonar®. Should the DBW determine at any point during the program that the EDCP is ineffective; the DBW would recommend to the legislature and appropriate regulatory agencies that EDCP activities cease. However, if the EDCP is effective, the DBW would submit supplemental environmental documentation that supports continuation of the EDCP (DBW 2000a) beyond the current permitted application period.

A. Project Activities

1. <u>Herbicides and Treatment Sites</u>

The EDCP is a program intended to control the non-native invasive aquatic weed, *Egeria densa* in the Delta. The Federal nexus for this activity is the USDA-ARS, which has the responsibility to conduct research and provide technical input into the control of nuisance weeds and agricultural pests. The DBW is the state lead for this project, with whom the USDA-ARS has contracted to conduct the application of the program. The currently existing EDCP treatment methods available to the DBW to utilize in the Delta include:

1. Reward® (active ingredient [a.i.] diquat dibromide [diquat], U.S. Environmental Protection Agency (EPA) Registration Number 10182-404)

2. Sonar®, three formulations which have been used:

    Sonar® A.S. (aqueous solution of a.i. fluridone, EPA Registration Number 67690-4

    Sonar® SRP ([slow release pellet] granular formulation of a.i. fluridone, EPA Registration Number 67690-3)

Sonar® PR ([precision release] granular formulation of a.i. fluridone, EPA Registration No. 67690-12)

3. Mechanical Harvesting (to be used for emergency control of infestation [*i.e.*, cases of extreme vegetation overgrowth or blockage of water intakes] only)

A total of 35 sites were selected in 2001 by the DBW to receive the control treatments for *Egeria densa* (DBW 2003). The sites were chosen based on the level of infestation and impacts to navigation in the Delta (see Table 1 [attached]).

The first two Sonar® formulations are not well suited to flowing water conditions and thus in past years were restricted to ten sites that had lower flows or less tidal influence than the remainder of the sites. The newer formulation of Sonar® PR pellets is better suited to conditions with higher flows and will be used in areas where the efficacy of the older formulations has been limited. DBW intends to use Sonar® PR in six sites (sites #4, #13, #17, #21-22, and #29 in Table 1) that had previously been treated with either Sonar® AS or Sonar® SRP.

In addition to the six sites described above, DBW intends to incorporate Sonar® PR as an alternative to the application of Reward® (*i.e.*, diquat) in any of 25 sites originally specified as Reward® application sites in the 2001 EDCP Environmental Impact Report (EIR) (sites #3, #5, #7, #9-12, #14-16, #18-20, #23-29, and #31-35 in Table 1).

DBW may select to use either Reward® or Sonar® PR at any one of these 25 sites, based on the ambient conditions at that site. Potentially all 25 sites, or 932 acres, could be treated with the Sonar® PR in a given treatment season rather than with Reward®, but this is unlikely given the variability of ambient conditions in the treatment areas. In addition, DBW is considering the sequential use of Reward®, followed by Sonar® PR as an application method in any of these 25 sites as well as in an additional four sites (sites #1-2, #6, and #8 in Table 1) when conditions warrant sequential treatment. Application of the follow-up Sonar® PR treatment would occur only when the initial Reward® treatment had dissipated to non-detectable levels in the water column, and subsequent regrowth of the *Egeria* had begun. Sonar® PR is most effective during the active growth phase of plants when the pigment carotene is being synthesized.

DBW has not stated in its project description that it intends to utilize a surfactant in the application of either the Sonar® or Reward® herbicide formulations proposed for the EDCP. NOAA Fisheries will base its analysis only on the effects of the EDCP utilizing the herbicides as formulated with the listed active ingredient.

2. <u>Treatment Protocol</u>

The original EDCP proposed treatment season extended from March 1 through November 30, although the August 11, 2003, biological opinion limited the actual treatment season to April 1 through October 15. Five crews, each consisting of a Specialist and a Technician, would carry out the control program. A Field Supervisor would manage daily operations, and assign spray locations to the crews on a weekly basis. The EDCP has identified 35 treatment sites for treatment during the application season (Table 1), and these sites would be prioritized according to impacts to navigation and the extent of obstruction. Treatment locations would be determined by weather and tidal conditions, the presence of agricultural crops, native vegetation, potable water intakes, and wildlife.

Since the issuance of the August 11, 2003 biological opinion, the application areas that DBW has prioritized for early treatment with fluridone are Frank's Tract (140 acres), Sandmound Slough (38 acres), Rhode Island (66 acres) and Little Potato Slough-Grindstone (8 acres), in that order. The Field Supervisor overseeing the EDCP has indicated that only three crews are available to treat the *Egeria densa* sites between April 1 and June 1.

Reward® and Sonar® A.S. will be applied from 19- to 21- foot air boats by subsurface applications through weighted hoses dragged below the water surface. Sonar® SRP and Sonar® PR will be applied to the treatment area with a broadcast spreader system. Each Reward® treatment site can be expected to be treated up to two times per a year. Sonar® will be applied over a six- to eight-week period by split or multiple applications to maintain a target concentration of 10 to 30 parts per billion (ppb) in the water column (per Sonar® label 2001). The total concentration of Sonar® applied will not exceed 150 ppb during an application season. Waste products, including both active and inert chemical ingredients and dead plants, would be left to sink into the substrate or be carried downstream by water flow. DBW operations are expected to result in dissolved oxygen (DO) levels remaining above 5.0 mg/L in open, fast-flowing waters. DBW operations also are expected in waters with DO levels of 3.0 mg/L or lower, particularly in enclosed, shallow, low-flow waters. Applications of herbicides will not be made in waters where the ambient DO is between 3.0 mg/L and 5.0 mg/L. No program chemicals will be discharged under high wind, high water flow or wave action, or other adverse conditions because these actions could result in the dispersion of applied chemicals beyond the intended target area, unintentionally exposing aquatic organisms and habitat to the herbicides.

Within a given treatment site, Reward® applications for the control of Egeria may be applied at 14-day intervals, as needed, to ensure control of missed plants and regrowth. Because only one third to one half of the water body area may be treated at one time as per Reward® label requirements, sequential spraying of different sections of the larger site are needed to ensure complete coverage of the treatment site.

B. Proposed Conservation Measures

DBW is obliged to follow the California Department of Pesticide Regulation (DPR) procedures for pesticide application, and to file a Notice of Intent (NOI) with the County Agricultural Commissioner of each county where they will be spraying. DBW staff will perform maintenance protocols that will minimize the chance of a potential chemical spill and adopt response plans that have been developed to contain chemical spills on land and in the water in the advent of a spill. In the event of an EDCP chemical herbicide spill, DFG, the County Agricultural Commissioners (CAC), the California Regional Water Quality Board – Central Valley (Regional Board), the Office of Emergency Services, and if applicable, the California Highway Patrol, County Health Departments, and the County Sheriff's Office will all be notified as needed.

In addition, DBW is required to adhere to the water quality monitoring protocols approved by the Regional Board per the criteria set forth in the NPDES General Permit. The General Permit does not specify numeric limits for water quality criteria, but rather gives narrative guidelines for dischargers to follow. The General Permit allows for temporary excursions above the numeric criteria listed in the California Toxics Rule (CTR) and EPA water quality criteria, as long as full restoration of water quality and beneficial uses of the receiving waters are returned to pre-treatment levels following completion of the action. However, DBW anticipates following both the EPA aquatic species toxicity limits and drinking water standards that follow:

- Reward® - the maximum labeled rate for water column concentration (i.e., aquatic species toxicity limit) is 370 ppb. The EPA drinking water concentration standard (Maximum Contaminant Level [MCL]) is 20 ppb. The DBW anticipates treating within the labeled rates the day of treatment and returning to EPA criteria within 24 hours after treatment.

- Sonar® - Application rates will be targeted to achieve a water column concentration of 10-40 ppb for a minimum of 45 days for maximum herbicidal efficacy. This concentration is below the drinking water standards set by the EPA of 150 ppb. Currently, there is not an aquatic species toxicity criterion for fluridone.

DBW also has Memoranda of Understanding with regional water agencies outlining additional application restrictions relating to drinking water intakes. Prior to any work within close proximity of drinking water intakes, DBW will develop a protocol for sampling post-treatment chemical residue around the intakes. Currently, label recommendations for Sonar® applications are allowed within ¼ mile of a potable water intake as long as individual applications do not exceed 20 ppb or exceed 150 ppb for the entire treatment season. Reward® concentration cannot exceed 20 ppb in drinking water.

As a requirement of the General Permit, the DBW will follow monitoring protocol terms imposed by the Regional Board. The general goals of the monitoring plan are to:

1. Document compliance with the requirements of the General Permit;

2. Support the development, implementation, and effectiveness of the implementation of Best Management Procedures (BMPs);

3. Demonstrate the full recovery of water quality and protection of beneficial uses of the receiving waters following completion of resource or pest management projects;

4. Identify and characterize aquatic pesticide application projects conducted by the DBW; and

5. Monitor all pesticides and application methods used by the DBW.

The monitoring program includes a daily log of site-specific information (*e.g.*, location, wind, chemicals used, location of listed species/species habitat), and pre- and post-treatment measurements of variables such as DO level, water temperature, turbidity, *Egeria* biomass and fragments, and chemical residues and toxicity. Three times each year, monitoring will be initiated at two sites in each of the four water categories (tidal, slow-moving, fast-flowing, dead-end slough) for each of the chemicals applied. Each chemical used in the EDCP will be subject to water quality and toxicity monitoring at least once each year. Other monitoring protocols relevant to listed salmonid species include recording field observations for any dead fish or native vegetation; visual assessment of water quality and photo documentation of native vegetation pre- and post-chemical control applications. The EDCP technical crew is trained in fish species identification and recognition of fish habitat in the Delta and associated waterways by the DBW environmental scientist assigned to the program.

C. Action Area

The project action area is the Sacramento-San Joaquin Delta region, an area of approximately 738,000 acres which is interlaced with hundreds of miles of waterways. The Delta is roughly bordered by the cities of Sacramento, Stockton, Tracy, and Pittsburgh. The Delta region also includes the cities of Antioch, Brentwood, Discovery Bay, Isleton, and about 14 unincorporated towns and villages. The Delta extends north to the I Street Bridge in Sacramento, west to the Suisun Marsh Salinity Control Gates near Pittsburgh, south to the junction of Highway 5 and 205 near Tracy, and east to the Port of Stockton (Appendix B Figure 1 [attached]). Within this region, DBW has designated 35 high priority sites (see Appendix A Table 1) which encompass nearly 3,000 acres of infested waterways. Of this acreage, DBW proposes to treat 1,733 infested acres, or 56% of the total infested acreage at the 35 high priority sites.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following Federally listed species (Evolutionarily Significant Units [ESUs] or DPSs) and designated critical habitat occur in the action area and may be affected by the proposed project:

Sacramento River winter-run Chinook salmon ESU
endangered (June 28, 2005, 70 FR 37160)

Sacramento River winter-run Chinook salmon critical habitat
(June 16, 1993, 58 FR 33212)

Central Valley spring-run Chinook salmon ESU
threatened (June 28, 2005, 70 FR 37160)

Central Valley spring-run Chinook salmon critical habitat
(September 2, 2005, 70 FR 52488)

Central Valley steelhead DPS
threatened (January 5, 2006 71 FR 834)

Central Valley steelhead designated critical habitat
(September 2, 2005, 70 FR 52488)

Southern DPS of North American green sturgeon (*Acipenser medirostris*)
threatened (April 7, 2006, 71 FR 17757)

A. Species and Critical Habitat Listing Status

NMFS has recently completed an updated status review of 16 salmon ESUs, including Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon, and concluded that the species' status should remain as previously listed (70 FR 37160). On January 5, 2006, NMFS published a final listing determination for ten steelhead DPSs, including Central Valley steelhead. The new listing concludes that Central Valley steelhead will remain listed as threatened (71 FR 834).

Sacramento River winter-run Chinook salmon were originally listed as threatened in August 1989, under emergency provisions of the ESA, and formally listed as threatened in November 1990 (55 FR 46515). The ESU consists of only one population that is confined to the upper Sacramento River in California's Central Valley. The Livingston Stone National Fish Hatchery population has been included in the listed Sacramento River winter-run Chinook salmon population as of June 28, 2005 (70 FR 37160). NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212). The ESU was reclassified as endangered on January 4, 1994 (59 FR 440), due to increased variability of run sizes, expected weak returns as a result of two small year classes in 1991 and 1993, and a 99 percent decline between 1966 and 1991. Critical habitat was delineated as the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Sacramento-San Joaquin Delta (Delta), including Kimball Island, Winter Island, and Brown's Island; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge. The critical habitat designation identifies those physical and biological features of the habitat that are essential to the conservation of the species and that may require special management consideration and protection. Within the Sacramento River this includes the river water, river bottom (including those areas and associated gravel used by winter-run Chinook salmon as spawning substrate), and adjacent riparian zone used by fry and juveniles for rearing. In the areas west of Chipps Island, including San Francisco Bay to the Golden Gate Bridge, this designation includes the estuarine water column, essential foraging habitat, and food resources utilized by winter-run Chinook salmon as part of their juvenile outmigration or adult spawning migrations.

Central Valley spring-run Chinook salmon were listed as threatened on September 16, 1999 (50 FR 50394). This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. The Feather River Hatchery (FRH) spring-run Chinook salmon population has been included as part of the Central Valley spring-run Chinook salmon ESU as of June 28, 2005 (70 FR 37160). Critical habitat was designated for spring-run Chinook salmon in the Central Valley on September 2, 2005 (70 FR 52488). Critical habitat includes the stream channels to the ordinary high water line within designated stream reaches such as those of the Feather and Yuba Rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear Creeks, and the Sacramento River and Delta.

Central Valley steelhead were listed as threatened under the ESA on March 19, 1998 (63 FR 13347). This DPS consists of steelhead populations in the Sacramento and San Joaquin River (inclusive of and downstream of the Merced River) basins in California's Central Valley. The Coleman National Fish Hatchery and FRH steelhead populations have been included in the listed population of steelhead as of January 5, 2006 (71 FR 834). These populations were previously included in the DPS but were not deemed essential for conservation and thus not part of the listed steelhead population. Critical habitat was designated for steelhead in the Central Valley on September 2, 2005 (70 FR 52488). Critical habitat includes the stream channels to the ordinary high water line within designated stream reaches such as those of the American, Feather, and Yuba Rivers, and Deer, Mill, Battle, Antelope, and Clear Creeks in the Sacramento River basin; the Calaveras, Mokelumne, Stanislaus, and Tuolumne Rivers in the San Joaquin River basin; and, the Sacramento and San Joaquin Rivers and Delta.

The southern DPS of North American green sturgeon was listed as threatened on April 7, 2006 (71 FR 17757). The listing becomes effective on July 7, 2006, and some or all of the ESA section 9(a) prohibitions against take will become effective upon the future issuance of protective regulations under section 4(d). The southern DPS presently contains only a single spawning population in the Sacramento River; individuals may occur in the action area. No critical habitat has been designated or proposed for the southern DPS of North American green sturgeon.

B. Species Life History and Population Dynamics

1. <u>Chinook Salmon</u>

a. *General Life History*

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a year or more following emergence, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Spring-run Chinook salmon exhibit a stream-type life history. Adults enter freshwater in the spring, hold over summer, spawn in fall, and the juveniles typically spend a year or more in freshwater before emigrating. Winter-run Chinook salmon are somewhat anomalous in that they have characteristics of both stream- and ocean-type races (Healey 1991). Adults enter freshwater in winter or early spring, and delay spawning until spring or early summer (stream-type). However, juvenile winter-run Chinook salmon migrate to sea after only 4 to 7 months of river life (ocean-type). Adequate instream flows and cool water temperatures are more critical for the survival of

Chinook salmon exhibiting a stream-type life history due to over summering by adults and/or juveniles.

Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes. Runs are designated on the basis of adult migration timing; however, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime and flow characteristics of their spawning site, and the actual time of spawning (Myers *et al.* 1998). Both spring-run and winter-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991).

During their upstream migration, adult Chinook salmon require streamflows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate streamflows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 38 °F to 56 °F (Bell 1991, California Department of Fish and Game (CDFG) 1998). Adult winter-run Chinook salmon enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate past Red Bluff Diversion Dam (RBDD) from mid-December through early August (NMFS 1997). The majority of the run passes RBDD from January through May, with the peak passage occuring in mid-March (Hallock and Fisher 1985). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type. Adult spring-run Chinook salmon enter the Delta from the Pacific Ocean beginning in January and enter natal streams from March to July (Myers *et al.* 1998). In Mill Creek, Van Woert (1964) noted that of 18,290 spring-run Chinook salmon observed from 1953 to 1963, 93.5 percent were counted between April 1 and July 14, and 89.3 percent were counted between April 29 and June 30. Typically, spring-run Chinook salmon utilize mid- to high elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature.

Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (U.S. Fish and Wildlife Service (FWS) 1995). The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. Bell (1991) identifies the preferred water temperature for adult spring-run Chinook salmon migration as 38 °F to 56 °F. Boles (1988) recommends water temperatures below 65 °F for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 70 °F, and that fish can become stressed as temperatures approach 70 °F. The Bureau of Reclamation (Reclamation) reports that spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 60 °F; although salmon can tolerate temperatures up to 65 °F before they experience an increased susceptibility to disease. The upper preferred water temperature for spawning Chinook salmon is

55 °F to 57 °F (Chambers 1956, Bjornn and Reiser 1995). Winter-run Chinook salmon spawning occurs primarily from mid-April to mid-August, with the peak activity occurring in May and June in the Sacramento River reach between Keswick dam and RBDD (Vogel and Marine 1991). The majority of winter-run Chinook salmon spawners are three years old. Physical Habitat Simulation Model (PHABSIM) results (FWS 2003a) indicate winter-run Chinook salmon suitable spawning velocities in the upper Sacramento River are between 1.54 feet per second (ft/s) and 4.10 ft/s, and suitable spawning substrates are between 1 and 5 inches in diameter. Initial habitat suitability curves (HSCs) show spawning suitability rapidly decreases for water depths greater than 3.13 feet (FWS 2003a). Spring-run Chinook salmon spawning occurs between September and October depending on water temperatures. Between 56 and 87 percent of adult spring-run Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Calkins *et al.* 1940, Fisher 1994). PHABSIM results indicate spring-run Chinook salmon suitable spawning velocities in Butte Creek are between 0.8 ft/s and 3.22 ft/s, and suitable spawning substrates are between 1 and 5 inches in diameter (FWS 2004). The initial HSC showed suitability rapidly decreasing for depths greater than 1.0 feet, but this effect was most likely due to the low availability of deeper water in Butte Creek with suitable velocities and substrates rather than a selection by spring-run Chinook salmon of only shallow depths for spawning (FWS 2004).

The optimal water temperature for egg incubation is 44 °F to 54 °F (Rich 1997). Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel percolation, and poor water quality. Studies of Chinook salmon egg survival to hatching conducted by Shelton (1995) indicated 87 percent of fry emerged successfully from large gravel with adequate subgravel flow. The length of time required for eggs to develop and hatch is dependent on water temperature and is quite variable. Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 61 °F and 37 °F, respectively, when the incubation temperature was held constant.

Winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994), generally at night. Spring-run Chinook salmon fry emerge from the gravel from November to March and spend about 3 to 15 months in freshwater habitats prior to emigrating to the ocean (Kjelson *et al.* 1981). Post-emergent fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on small insects and crustaceans.

When juvenile Chinook salmon reach a length of 50 to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures. In the mainstems of larger rivers, juveniles tend to migrate along the margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 9 to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Stream flow and/or turbidity increases in the upper Sacramento River basin are thought to stimulate emigration. Emigration of juvenile winter-run Chinook salmon past RBDD may begin as early as mid-July, typically peaks in September, and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997). From 1995 to 1999, all winter-run Chinook salmon outmigrating as fry passed RBDD by October, and all outmigrating pre-smolts and smolts passed RBDD by March (Martin *et al.* 2001). The emigration timing of Central Valley spring-run Chinook salmon is highly variable (CDFG 1998). Some fish may begin emigrating soon after emergence from the gravel, whereas others over summer and emigrate as yearlings with the onset of intense fall storms (CDFG 1998). The emigration period for spring-run Chinook salmon extends from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period (CDFG 1998).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, Central Valley spring-run Chinook salmon juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin *et al.* 1997, Snider 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, Sommer *et al.* 2001; MacFarlane and Norton 2002). Shallow water habitats are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 54 °F to 57 °F (Brett 1952). In Suisun and San Pablo Bays water temperatures reach 54 °F by February in a typical year. Other portions of the Delta (*i.e.*, South Delta and Central Delta) can reach 70 °F by February in a dry year. However, cooler temperatures are usually the norm until after the spring runoff has ended.

As Chinook salmon fry and fingerlings mature, they prefer to rear further downstream where ambient salinity may reach 1.5 to 2.5 parts per thousand (Healy 1980, 1982; Levings *et al.* 1986). Juvenile winter-run Chinook salmon occur in the Delta from October through early May based on data collected from trawls, beach seines, and salvage records at the Central Valley Project (CVP) and State Water Project (SWP) pumping facilities (CDFG 1998). The peak of listed juvenile salmon arrivals in the Delta generally occurs from January to April, but may extend into June. Upon arrival in the Delta, winter-run Chinook salmon spend the first 2 months rearing in the more upstream, freshwater portions of the Delta (Kjelson *et al.* 1981, 1982). Data from the CVP and SWP salvage records indicate that most spring-run Chinook salmon smolts are present in the Delta from mid-March through mid-May depending on flow conditions (CDFG 2000).

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1982, Levings 1982, Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle *et al.* (1986) reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Available data indicates that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean. Winter-run Chinook salmon fry remain in the estuary (Delta/Bay) until they reach a fork length of about 118 mm (*i.e.*, 5 to 10 months of age) and then begin emigrating to the ocean perhaps as early as November and continuing through May (Fisher 1994, Myers *et al.* 1998). Little is known about estuarine residence time of spring-run Chinook salmon. Juvenile Chinook salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallones (MacFarlane and Norton 2002). Based on the mainly ocean-type life history observed (*i.e.*, fall-run Chinook salmon) MacFarlane and Norton (2002) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry. Spring-run yearlings are larger in size than fall-run yearlings and are ready to smolt upon entering the Delta; therefore, they are believed to spend little time rearing in the Delta.

b. *Population Trend – Sacramento River Winter-run Chinook Salmon*

The distribution of winter-run Chinook salmon spawning and rearing historically was limited to the upper Sacramento River and its tributaries, where spring-fed streams allowed for spawning, egg incubation, and rearing in cold water (Slater 1963; Yoshiyama *et al.* 1998). The headwaters of the McCloud, Pit, and Little Sacramento Rivers, and Hat and Battle Creeks, historically provided clean, loose gravel; cold, well-oxygenated water; and optimal stream flows in riffle habitats for spawning and incubation. These areas also provided the cold, productive waters necessary for egg and fry development and survival, and juvenile rearing over the summer. The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which has its own impediments to upstream migration (*i.e.*, the fish weir at the Coleman National Fish Hatchery and other small hydroelectric facilities situated upstream of the weir) (Moyle *et al.* 1989, NMFS 1997, 1998). Approximately, 299 miles of tributary spawning habitat in the upper Sacramento River is now inaccessible to winter-run Chinook salmon. Yoshiyama *et al.* (2001) estimated that in 1938, the Upper Sacramento had a "potential spawning capacity" of 14,303 redds. Most components of the winter-run Chinook salmon life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River.

Following the construction of Shasta Dam, the number of winter-run Chinook salmon initially declined but recovered during the 1960s. The initial recovery was followed by a steady decline from 1969 through the late 1980s following the construction of the RBDD. Since 1967, the estimated adult winter-run Chinook salmon population ranged from 117,808 in 1969, to 186 in 1994 (FWS 2001a,b; CDFG 2002b). The population declined from an average of 86,000 adults in 1967 to 1969 to only 1,900 in 1987 to 1989, and continued to remain low, with an average of 2,500 fish for the period from 1998 to 2000 (see Appendix B: Figure 2). Between the time Shasta Dam was built and the listing of winter-run Chinook salmon as endangered, major impacts to the population occurred from warm water releases from Shasta Dam, juvenile and adult passage constraints at RBDD, water exports in the southern Delta, acid mine drainage from Iron Mountain Mine, and entrainment at a large number of unscreened or poorly-screened water diversions (NMFS 1997, 1998).

Population estimates in 2001 (8,224), 2002 (7,441), 2003 (8,218), and 2004 (7,701) show a recent increase in the escapement of winter-run Chinook salmon. The 2003 run was the highest since the listing. Winter-run Chinook salmon abundance estimates and cohort replacement rates since 1986 are shown in Table 2. The population estimates from the RBDD counts has increased since 1986 (CDFG 2004a), there is an increasing trend in the 5 year moving average (491 from 1990-1994 to 5,451 from 1999-2003); and the 5 year moving average of cohort replacement rates has increased and appears to have stabilized over the same period (Table 2).

Table 2. Winter-run Chinook salmon population estimates from RBDD counts, and corresponding cohort replacement rates for the years since 1986 (CDFG 2004a, Grand Tab CDFG February 2005).

Year	Population Estimate (RBDD)	5-Year Moving Average of Population Estimate	Cohort Replacement Rate	5-Year Moving Average of Cohort Replacement Rate	NMFS Calculated Juvenile Production Estimate (JPE)[a]
1986	2,596	-	-	-	
1987	2,186	-	-	-	
1988	2,885	-	-	-	
1989	696	-	0.27	-	
1990	433	1,759	0.20	-	
1991	211	1,282	0.07	-	40,100
1992	1,240	1,092	1.78	-	273,100
1993	387	593	0.90	0.64	90,500
1994	186	491	0.88	0.77	74,500
1995	1,297	664	1.05	0.94	338,107
1996	1,337	889	3.45	1.61	165,069
1997	880	817	4.73	2.20	138,316
1998	3,002	1,340	2.31	2.48	454,792
1999	3,288	1,961	2.46	2.80	289,724
2000	1,352	1,972	1.54	2.90	370,221
2001	8,224	3,349	2.74	2.76	1,864,802
2002	7,441	4,661	2.26	2.22	2,136,747
2003	8,218	5,705	6.08	3.02	1,896,649
2004	7,701	6,587	0.94	2.71	881,719
2005	15,730	9,463	2.11	2.83	3,831,286
median	1,769	1,550	1.78	2.49	338,107

[a]JPE estimates were derived from NMFS calculations utilizing RBDD winter-run counts through 2001, and carcass counts thereafter for deriving adult escapement numbers.

c. *Status - Sacramento River Winter-run Chinook Salmon*

Numerous factors have contributed to the decline of winter-run Chinook salmon through degradation of spawning, rearing and migration habitats. The primary impacts include blockage of historical habitat by Shasta and Keswick Dams, warm water releases from Shasta Dam, juvenile and adult passage constraints at RBDD, water exports in the southern Delta, heavy metal contamination from Iron Mountain Mine, high ocean harvest rates, and entrainment in a large number of unscreened or poorly screened water diversions within the Central Valley. Secondary factors include smaller water manipulation facilities and dams, loss of rearing habitat in the lower Sacramento River and Delta from levee construction, marshland reclamation, and interactions with, and predation by, introduced non-native species (NMFS 1997, 1998).

Since the listing of winter-run Chinook salmon, several habitat problems that led to the decline of the species have been addressed and improved through restoration and conservation actions. The impetus for initiating restoration actions stem primarily from the following: (1) ESA section 7 consultation Reasonable and Prudent Alternatives (RPAs) on temperature, flow, and operations of the CVP and SWP; (2) Regional Board decisions requiring compliance with Sacramento River water temperatures objectives which resulted in the installation of the Shasta Temperature Control Device in 1998; (3) a 1992 amendment to the authority of the CVP through the Central Valley Improvement Act (CVPIA) to give fish and wildlife equal priority with other CVP objectives; (4) fiscal support of habitat improvement projects from the California Bay Delta Authority (CBDA) Bay-Delta Program (*e.g.*, installation of a fish screen on the Glenn-Colusa Irrigation District (GCID) diversion); (5) establishment of the CBDA Environmental Water Account (EWA); (6) Environmental Protection Agency (EPA) actions to control acid mine runoff from Iron Mountain Mine; and (7) ocean harvest restrictions implemented in 1995.

The susceptibility of winter-run Chinook salmon to extinction remains linked to the elimination of access to most of their historical spawning grounds and the reduction of their population structure to a small population size. Recent trends in winter-run Chinook salmon abundance and cohort replacement are positive and may indicate some recovery since the listing. Although NMFS recently proposed that this ESU be upgraded from endangered to threatened status, it made the decision in its Final Listing Determination (June 28, 2005, 70 FR 37160) to continue to list the Sacramento River winter-run Chinook salmon ESU as endangered. This population remains below the recovery goals established for the run (NMFS 1997, 1998) and the naturally spawned component of the ESU is dependent on one extant population in the Sacramento River. In general, the recovery criteria for winter-run Chinook salmon include a mean annual spawning abundance over any 13 consecutive years of at least 10,000 females with a concurrent geometric mean of the cohort replacement rate greater than 1.0.

d. *Population Trend – Central Valley Spring-run Chinook Salmon*

Historically, the predominant salmon run in the Central Valley was the spring-run Chinook salmon, which occupied the upper and middle reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit Rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1874, Rutter 1904, Clark 1929). The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). Before the construction of Friant Dam, nearly 50,000 adults were counted in the San Joaquin River alone (Fry 1961). Construction of other low elevation dams in the foothills of the Sierras on the American, Mokelumne, Stanislaus, Tuolumne and Merced Rivers extirpated Central Valley spring-run Chinook salmon from these watersheds. Naturally-spawning populations of Central Valley spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (CDFG 1998).

On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRH. In 2002, the FRH reported 4,189 returning spring-run Chinook salmon, which is 22 percent below the 10-year average of 4,727 fish. However, coded-wire tag (CWT) information from these hatchery returns indicates substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to hatchery practices. Because Chinook salmon are not temporally separated in the hatchery, spring-run and fall-run Chinook salmon are spawned together, thus compromising the genetic integrity of the spring-run Chinook salmon stock. The number of naturally spawning spring-run Chinook salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from two fish in 1978 to 2,908 in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run and fall-run Chinook salmon (NMFS 2003, Good *et al.* 2005). For the reasons discussed above, the Feather River spring-run Chinook population numbers are not included in the following discussion of ESU abundance.

Since 1969, the Central Valley spring-run Chinook salmon ESU (excluding Feather River fish) has displayed broad fluctuations in abundance ranging from 25,890 in 1982 to 1,403 in 1993 (CDFG unpublished data). Even though the abundance of fish may increase from one year to the next, the overall average population trend has a negative slope during this time period (see Appendix B: Figure 3). The average abundance for the ESU was 12,499 for the period of 1969 to 1979, 12,981 for the period of 1980 to 1990, and 6,542 for the period of 1991 to 2001. In 2002 and 2003, total run size for the ESU was 13,218 and 8,775 adults respectively, well above the 1991-2001 average.

Evaluating the ESU as a whole masks significant changes that are occurring among basin metapopulations. For example, while the mainstem Sacramento River population has undergone a significant decline, the tributary populations have demonstrated substantial increases. The average population abundance of Sacramento River mainstem spring-run Chinook salmon has recently declined from a high of 12,107 fish for the period 1980 to 1990, to a low of 609 for the period between 1991 and 2001, while the average abundance of Sacramento River tributary populations increased from a low of 1,227 to a high of 5,925 over the same period. Although tributaries such as Mill and Deer Creeks have shown positive escapement trends since 1991, recent escapements to Butte Creek, including 20,259 in 1998, 9,605 in 2001 and 8,785 in 2002, are responsible for the overall increase in tributary abundance (CDFG 2002a, 2004b; CDFG, unpublished data). The Butte Creek estimates, which account for the majority of this ESU, do not include prespawning mortality. In the last several years as the Butte Creek population has increased, mortality of adult spawner has increased from 21 percent in 2002 to 60 percent in 2003 due to over-crowding and diseases associated with high water temperatures. This trend may indicate that the population in Butte Creek may have reached its carrying capacity (Ward *et al.* 2003) or has reached historical population levels (*i.e.*, Deer and Mill creeks). Table 3 shows the population trends from the three tributaries since 1986, including the moving 5 year average, cohort replacement rate, and estimated JPE.

Table 3. Spring-run Chinook salmon population estimates from CDFG Grand Tab (February 2005) with corresponding cohort replacement rates for years since 1986.

Year	Sacramento River Basin Escapement Run Size	5-Year Moving Average of Population Estimate	Cohort Replacement Rate	5-Year Moving Average of Cohort Replacement Rate	NMFS Calculated JPE[a]
1986	24,263	-	-	-	4,396,998
1987	12,675	-	-	-	2,296,993
1988	12,100	-	-	-	2,192,790
1989	7,085	-	0.29	-	1,283,960
1990	5,790	12,383	0.46	-	1,049,277
1991	1,623	7,855	0.13	-	294,124
1992	1,547	5,629	0.22	-	280,351
1993	1,403	3,490	0.24	0.27	254,255
1994	2,546	2,582	1.57	0.52	461,392
1995	9,824	3,389	6.35	1.70	1,780,328
1996	2,701	3,604	1.93	2.06	489,482
1997	1,431	3,581	0.56	2.13	259,329
1998	24,725	8,245	2.52	2.58	4,480,722
1999	6,069	8,950	2.25	2.72	1,099,838
2000	5,457	8,077	3.81	2.21	988,930
2001	13,326	10,202	0.54	1.94	2,414,969
2002	13,218	12,559	2.18	2.26	2,395,397
2003	8,902	9,9394	1.63	2.08	1,613,241
2004	9,872	10,155	0.74	1.78	1,789,027
2005	14,312	11,926	1.08	1.23	2,593,654
median	7,994	9,172	1.33	1.74	1,448,601

[a]NMFS calculated the spring-run JPE using returning adult escapement numbers to the Sacramento River basin prior to the opening of the RBDD for spring-run migration, and then escapement to Mill, Deer, and Butte Creeks for the remaining period, and assuming a female to male ratio of 6:4 and pre-spawning mortality of 25 percent. NMFS utilized the female fecundity values in Fisher (1994) for spring-run Chinook salmon (4,900 eggs/female). The remaining survival estimates used the winter-run values for calculating JPE.

The extent of spring-run Chinook salmon spawning in the mainstem of the upper Sacramento River is unclear. Very few spring-run Chinook salmon redds (less than 15 per year) were observed from 1989 through 1993, and none in 1994, during aerial redd counts (FWS 2003a). Recently, the number of redds in September has varied from 29 to 105 during 2001 though 2003 depending on the number of survey flights (CDFG, unpublished data). In 2002, based on RBDD ladder counts, 485 spring-run Chinook salmon adults may have spawned in the mainstem Sacramento River or entered upstream tributaries such as Clear or Battle Creek (CDFG 2004b). In 2003, no adult spring-run Chinook salmon were believed to have spawned in the mainstem Sacramento River. Due to geographic overlap of ESUs and resultant hybridization since the construction of Shasta Dam, Chinook salmon that spawn in the mainstem Sacramento River during September are more likely to be identified as early fall-run rather than spring-run Chinook salmon.

e. *Status of Spring-run Chinook Salmon*

The initial factors that led to the decline of spring-run Chinook salmon in the Central Valley were related to the loss of upstream habitat behind impassable dams. Since this initial loss of habitat, other factors have contributed to the instability of the spring-run Chinook salmon population and have negatively affected the ESU's ability to recover. These factors include a combination of physical, biological, and management factors such as climatic variation, water management activities, hybridization with fall-run Chinook salmon, predation, and over-harvesting (CDFG 1998). Since spring-run Chinook salmon adults must hold over for months in small tributaries before spawning, they are much more susceptible to the effects of high water temperatures.

During the drought from 1986 to 1992, Central Valley spring-run Chinook salmon populations declined substantially. Reduced flows resulted in warm water temperatures that impacted adults, eggs, and juveniles. For adult spring-run Chinook salmon, reduced instream flows delayed or completely blocked access to holding and spawning habitats. Water management operations (*i.e.,* reservoir release schedules and volumes) and the unscreened and poorly-screened diversions in the Sacramento River, Delta, and tributaries compounded drought-related problems by reducing river flows, elevating river temperatures, and entraining juveniles into the diversions.

Several actions have been taken to improve habitat conditions for spring-run Chinook salmon, including: improved management of Central Valley water (*e.g.*, through use of CALFED EWA and CVPIA (b)(2) water accounts); implementing new and improved screen and ladder designs at major water diversions along the mainstem Sacramento River and tributaries; and changes in ocean and inland fishing regulations to minimize harvest. Although protective measures likely have contributed to recent increases in spring-run Chinook salmon abundance, the ESU is still below levels observed from the 1960s through 1990. Threats from hatchery production (*i.e.*, competition for food between naturally-spawned and hatchery fish, run hybridization and genomic homogenization), climatic variation, high temperatures, predation, and water diversions still persist. Because the Central Valley spring-run Chinook salmon ESU is confined to relatively few remaining watersheds and continues to display broad fluctuations in abundance, the population is at a moderate risk of extinction.

2. Steelhead

a. *General Life History*

Steelhead can be divided into two life history types, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Stream-maturing steelhead enter freshwater in a sexually immature condition and require several months to mature and spawn, whereas ocean-maturing steelhead enter freshwater with well-developed gonads and spawn shortly after river entry. These two life history types are more commonly referred to by their season of freshwater entry (*i.e.*, summer (stream-maturing) and winter (ocean-maturing) steelhead). Only winter steelhead currently are found in Central Valley rivers and streams (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento river system prior to the commencement of large-scale dam construction in the 1940s (Interagency Ecological Program (IEP) Steelhead Project Work Team 1999). At present, summer steelhead are found only in North Coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity River systems (McEwan and Jackson 1996).

Winter steelhead generally leave the ocean from August through April, and spawn between December and May (Busby *et al.* 1996). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures. In general, the preferred water temperature for adult steelhead migration is 46 °F to 52 °F (McEwan and Jackson 1996, Myrick 1998, and Myrick and Cech 2000). Thermal stress may occur at temperatures beginning at 66 °F and mortality has been demonstrated at temperatures beginning at 70 °F, although some races of steelhead may have higher or lower temperature tolerances depending upon their evolutionary history. Lower latitudes and elevations would tend to favor fish tolerant of higher ambient temperatures (see Matthews and Berg (1997) for discussion of *O. mykiss* from Sespe Creek in Southern California). The preferred water temperature for steelhead spawning is 39 °F to 52 °F, and the preferred water temperature for steelhead egg incubation is 48 °F to 52 °F (McEwan and Jackson 1996, Myrick 1998, Myrick and Cech 2000). The minimum stream depth necessary for successful upstream migration is 13 cm (Thompson 1972). Preferred water velocity for upstream migration is in the range of 40-90 cm/s, with a maximum velocity, beyond which upstream migration is not likely to occur, of 240 cm/s (Thompson 1972, Smith 1973).

Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Nickelson *et al.* 1992, Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapolov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams. Most steelhead spawning takes place from late December through April, with peaks from January though March (Hallock *et al.* 1961). Steelhead spawn in cool, clear streams featuring suitable gravel size, depth, and current velocity, and may spawn in intermittent streams as well (Everest 1973, Barnhart 1986).

The length of the incubation period for steelhead eggs is dependent on water temperature, DO concentration, and substrate composition. In late spring and following yolk sac absorption, fry emerge from the gravel and actively begin feeding in shallow water along stream banks (Nickelson *et al.* 1992).

Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-the-year also are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Shirvell 1990, Meehan and Bjornn 1991). Some older juveniles move downstream to rear in large tributaries and mainstem rivers (Nickelson *et al.* 1992). Juveniles feed on a wide variety of aquatic and terrestrial insects (Chapman and Bjornn 1969), and older juveniles sometimes prey upon emerging fry.

Steelhead generally spend two years in freshwater before emigrating downstream (Hallock *et al.* 1961, Hallock 1989). Rearing steelhead juveniles prefer water temperatures of 45 °F to 58 °F and have an upper lethal limit of 75 °F. They can survive up to 81 °F with saturated DO conditions and a plentiful food supply. Reiser and Bjornn (1979) recommended that DO concentrations remain at or near saturation levels with temporary reductions no lower than 5.0 mg/l for successful rearing of juvenile steelhead. During rearing, suspended and deposited fine sediments can directly affect salmonids by abrading and clogging gills, and indirectly cause reduced feeding, avoidance reactions, destruction of food supplies, reduced egg and alevin survival, and changed rearing habitat (Reiser and Bjornn 1979). Bell (1973) found that silt loads of less than 25 mg/l permit good rearing conditions for juvenile salmonids.

Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Emigrating Central Valley steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Some may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the sea. Barnhart (1986) reported that steelhead smolts in California range in size from 140 to 210 mm (fork length). Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento River Basin migrate downstream during most months of the year, but the peak period of emigration occurred in the spring, with a much smaller peak in the fall.

b. *Population Trends – Central Valley Steelhead*

Steelhead historically were well-distributed throughout the Sacramento and San Joaquin Rivers (Busby *et al.* 1996). Steelhead were found from the upper Sacramento and Pit River systems (now inaccessable due to Shasta and Keswick Dams) south to the Kings and possibly the Kern River systems (now inaccessible due to extensive alterations from numerous water diversion projects) and in both east and west-side Sacramento River tributaries (Yoshiyama *et al.* 1996). The present distribution has been greatly reduced (McEwan and Jackson 1996). The California Advisory Committee on Salmon and Steelhead (1988) reported a reduction of steelhead habitat from 6,000 miles historically to 300 miles currently. Historically, steelhead probably ascended Clear Creek past the French Gulch area, but access to the upper basin was blocked by Whiskeytown Dam in 1964 (Yoshiyama *et al.* 1996).

Historic Central Valley steelhead run sizes are difficult to estimate given the paucity of data, but may have approached 1 to 2 million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally-spawned steelhead populations in the upper Sacramento River have declined substantially (see Appendix B: Figure 4). Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River, upstream of the Feather River. Steelhead counts at the RBDD declined from an average of 11,187 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

Nobriga and Cadrett (2003) compared CWT and untagged (wild) steelhead smolt catch ratios at Chipps Island trawl from 1998 through 2001 to estimate that about 100,000 to 300,000 steelhead juveniles are produced naturally each year in the Central Valley. In the draft *Updated Status Review of West Coast Salmon and Steelhead* (NMFS 2003), the Biological Review Team (BRT) made the following conclusion based on the Chipps Island data:

> "If we make the fairly generous assumptions (in the sense of generating large estimates of spawners) that average fecundity is 5,000 eggs per female, 1 percent of eggs survive to reach Chipps Island, and 181,000 smolts are produced (the 1998-2000 average), about 3,628 female steelhead spawn naturally in the entire Central Valley. This can be compared with McEwan's (2001) estimate of 1 million to 2 million spawners before 1850, and 40,000 spawners in the 1960s".

The only consistent data available on steelhead numbers in the San Joaquin River basin come from CDFG mid-water trawling samples collected on the lower San Joaquin River at Mossdale. These data (see Appendix B, Figure 5) indicate a decline in steelhead numbers in the early 1990s, which have remained low through 2002 (CDFG 2003). In 2003, a total of 12 steelhead smolts were collected at Mossdale (CDFG, unpublished data).

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks and the Yuba River. Populations may exist in Big Chico and Butte Creeks and a few wild steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996).

Recent snorkel surveys (1999 to 2002) indicate that steelhead are present in Clear Creek (J. Newton, FWS, pers. comm. 2002, as reported in NMFS 2003, Good *et al.* 2005). Because of the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not been estimated.

Until recently, steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, Calaveras, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (Demko *et al.* 2000). After 4 years of operating a fish counting weir on the Stanislaus River only two adult steelhead have been observed moving upstream, although several large rainbow trout have washed up on the weir in late winter (S.P. Cramer 2005). It is possible that naturally spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, if not abundant, throughout accessible streams and rivers in the Central Valley (NMFS 2003, Good *et al.* 2005).

c. *Status - Central Valley Steelhead*

Both the BRT (NMFS 2003, Good *et al.* 2005) and the Artificial Propagation Evaluation Workshop (69 FR 33102) concluded that the Central Valley steelhead DSP presently is "in danger of extinction". Steelhead have been extirpated from most of their historical range in this region. Habitat concerns in this DSP focus on the widespread degradation, destruction, and blockage of freshwater habitat within the region, and water allocation problems. Widespread hatchery steelhead production within this DSP also raises concerns about the potential ecological interactions between introduced stocks and native stocks. Because the Central Valley steelhead population has been fragmented into smaller isolated tributaries without any large source population and the remaining habitat continues to be degraded by water diversions, the population remains at an elevated risk for future population declines.

3. North American Green Sturgeon

a. *General Life History*

The North American green sturgeon have morphological characteristics of both cartilaginous fish and bony fish. The fish has some morphological traits similar to sharks, such as a cartilaginous skeleton, heterocercal caudal fin, spiracles, spiral valve intestine, electro-sensory pores on its snout and an enlarged liver. However, like more modern teleosts, it has five gill arches contained within one branchial chamber, covered by one opercular plate and a functional swim bladder for bouyancy control, Adult green sturgeon have a maximum fork length of 2.3 meters and 159 kg body weight (Miller and Lee 1980, Moyle *et al.* 1992). It is believed that green sturgeon can live at least 60 years, based on data from the Klamath River (Emmett *et al.* 1991).

The green sturgeon is the most widely distributed of the *acipenseridae*. They are amphi-Pacific and circumboreal, ranging from the inshore waters of Baja California northwards to the Bering

Sea and then southwards to Japan. They have been recorded from at least six different countries: Mexico, United States, Canada, Russia (Sakhalin Island), Japan and Korea (Emmett *et al.* 1991, Moyle *et al.* 1992). Although widely distributed, they are not very abundant in comparison to the sympatric white sturgeon (*Acipenser transmontanus*).

(1) ***Adult Distribution and Feeding***. In North America, spawning populations of green sturgeon are currently found in only three river systems: the Sacramento and Klamath Rivers in California and the Rogue River in southern Oregon. Spawning has only been reported in one Asian river, the Tumin River in eastern Asia. Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. Data from commercial trawl fisheries and tagging studies indicate that the green sturgeon occupy waters within the 110 meter contour (NMFS 2005). During the late summer and early fall, subadults and nonspawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Emmett *et al.* 1991). Particularly large concentrations occur in the Columbia River estuary, Willapa Bay, and Grays Harbor, with smaller aggregations in San Francisco and San Pablo Bays (Emmett *et* al 1991, Moyle *et al.* 1992, Beamesderfer *et al.* 2004). Recent acoustical tagging studies on the Rogue River (Erickson *et al.* 2002) have shown that adult green sturgeon will hold for as much as 6 months in deep (> 5m), low gradient reaches or off channel sloughs or coves of the river during summer months when water temperatures were between 15 °C and 23 °C. When ambient temperatures in the river dropped in autumn and early winter (<10 °C) and flows increased, fish moved downstream and into the ocean.

Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid and grass shrimp, and amphipods (Radtke 1966, Stuart personal observation). Adult sturgeon caught in Washington state waters were found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle *et al.* 1992).

(2) ***Spawning***. Adult green sturgeon are gonochoristic (sex genetically fixed), oviparous and iteroparous. They are believed to spawn every 3 to 5 years and reach sexual maturity only after several years of growth (10 to 15 years based on sympatric white sturgeon sexual maturity). Younger females may not spawn the first time they undergo oogenesis and reabsorb their gametes. Adult female green sturgeon produce between 60,000 and 140,000 eggs, depending on body size, with a mean egg diameter of 4.3 mm (Moyle *et al.* 1992, Van Eenennaam *et al.* 2001). They have the largest egg size of any sturgeon, and the volume of yolk ensures an ample supply of energy for the developing embryo. The eggs themselves are slightly adhesive, much less so than the sympatric white sturgeon, and are more dense than than those of white sturgeon (Kynard *et al.* 2005). Adults begin their upstream spawning migrations into freshwater in late February with spawning occuring between March and July. Peak spawning is believed to occur between April and June in deep, turbulent, mainstem channels over large cobble and rocky substrates with crevices and interstices. Females broadcast spawn their eggs over this substrate, and the fertilized eggs sink into the interstices of the substrate where they develop further (Kynard *et al.* 2005).

(3) ***Egg Development.*** Green sturgeon larvae hatched from fertilized eggs after approximately 169 hours at a water temperature of 15 °C (Van Eenennaam *et al.* 2001, Deng *et al.* 2002), which

is similar to the sympatric white sturgeon development rate (176 hours). Studies conducted at the University of California, Davis by Van Eenennaam *et al.* (2005) indicated that an optimum range of water temperature for egg development ranged between 14 °C and 17 °C. Temperatures over 23 °C resulted in 100 percent mortality of fertilized eggs before hatching. Eggs incubated at water temperatures between 17.5 °C and 22 °C resulted in elevated mortalities and an increased occurrence of morphological abnormalities in those eggs that did hatch. At incubation temperatures below 14 °C, hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so.

(4) ***Early Development.*** Newly hatched green sturgeon are approximately 12.5 to 14.5 mm in length and have a large ovoid yolk sac that supplies nutritional energy until exogenous feeding occurs. The larvae are less developed in their morphology than older juveniles and external morphology resembles a "tadpole" with a continuous fin fold on both the dorsal and ventral sides of the caudal trunk. The eyes are well developed with differentiated lenses and pigmentation.

Olfactory and auditory vesicles are present while the mouth and respiratory structures are only shallow clefts on the head. At 10 days of age, the yolk sac has become greatly reduced in size and the larvae initiates exogenous feeding through a functional mouth. The fin folds have become more developed and formation of fin rays begins to occur in all fin tissues. By 45 days of age, the green sturgeon larvae have completed their metamorphosis, which is characterized by the development of dorsal, lateral, and ventral scutes, elongation of the barbels, rostrum, and caudal peduncle, reabsorption of the caudal and ventral fin folds, and the development of fin rays. The juvenile fish resembles the adult form, including the dark olive coloring, with a dark mid-ventral stripe (Deng *et al.* 2002).

Green sturgeon larvae do not exhibit the initial pelagic swim–up behavior characteristic of other *acipenseridae*. The are strongly oriented to the bottom and exhibit nocturnal activity patterns. After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al.* 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile fish continue to exhibit nocturnal behavioral beyond the metamorphosis from larvae to juvenile stages. Kynard *et al.*'s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first 6 months of life. When ambient water temperatures reached 8 °C, downstream migrational behavior diminished and holding behavior increased. This data suggests that 9 to 10 month old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds.

Green sturgeon juveniles tested under laboratory conditions had optimal bioenergetic performance (*i.e.* growth, food conversion, swimming ability) between 15 °C and 19 °C under either full or reduced rations (Mayfield and Cech 2004). This temperature range overlaps the egg incubation temperature range for peak hatching success previously discussed. Ambient water temperature conditions in the Rogue and Klamath River systems range from 4 °C to approximately 24 °C. The Sacramento River has similar temperature profiles, and, like the previous two rivers, is a regulated system with several dams controlling flows on its mainstem (Shasta and Keswick dams), and its tributaries (Whiskeytown, Oroville, Folsom, and Nimbus dams).

Larval and juvenile green sturgeon are subject to predation by both native and introduced fish species. Smallmouth bass (*Micropterus dolmoides*) have been recorded on the Rogue River as preying on juvenile green sturgeon, and prickly sculpin (*Cottus asper*) have been shown to be an effective predator on the larvae of sympatric white sturgeon (Gadomski and Parsley 2005). This latter study also indicated that the lowered turbidity found in tailwater streams and rivers due to dams increased the effectiveness of sculpin predation on sturgeon larvae under laboratory conditions.

b. *Population Trends –Southern DPS of North American Green Sturgeon*

Known historic and current spawning occurs in the Sacramento River (Adams *et al.* 2002, Beamesderfer *et al.* 2004). Currently, upstream migrations of sturgeon are halted by Keswick and Shasta Dams on the mainstem of the Sacramento River. Although no historical accounts exist for identified green sturgeon spawning occuring above the current dam sites, suitable spawning habitat existed and based on habitat assessments done for Chinook salmon, the geographic extent of spawning has been reduced due to the impassable barriers constructed on the river.

Spawning on the Feather River is suspected to have occurred in the past due to the continued presence of adult green sturgeon in the river below Oroville Dam. This continued presence of adults below the dam suggests that fish are trying to migrate to upstream spawning areas now blocked by the dam which was constructed in 1968.

Spawning in the San Joaquin River system has not been recorded historically or observed recently, but alterations of the San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced Rivers) and its mainstem occurred early in the european settlement of the region. During the later half of the 1800s impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for approximately a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. It is likely that both white and green sturgeon utilized the San Joaquin River basin for spawning prior to the onset of european influence, based on past use of the region by populations of Central Valley spring-run Chinook salmon and steelhead. These two populations of salmonids have either been extirpated or greatly diminished in their use of the San Joaquin River basin over the past two centuries.

The size of the population of green sturgeon is difficult to estimate due to a lack of data specific for this fish. However, inferences from the commercial and sport fisheries harvest can be used to estimate population trends over time. Based on the harvest numbers, green sturgeon catch has decreased from a high of 9,065 in 1986 to 512 in 2003. The greatest decreases in harvest were for commercial gears in the Columbia River, Willapa Bay, and Greys Harbor. The decrease was attributed to changes in the regulatory statutes for sturgeon harvest (Adams *et al.* 2002). Catch rates for the Hoopa and Yurok tribal harvests remained unchanged during this same period and accounted for approximately 59 percent of the total harvest in 2003 (NMFS 2005). Entrainment numbers at the SWP and CVP pumping facilities in the south Delta have been consistently lower than their levels in the mid -1970s (SWP) and the mid-1980s (CVP). Prior to 1986, the SWP (1968 -2001) averaged 732 green sturgeon salvaged per year, which dropped to 47 per year after 1986. The CVP (1980-2001) showed similar declines in its salvage rate for green sturgeon, 889 per year prior to 1986 and 32 per year after 1986.

c. *Status –Southern DPS of North American Green Sturgeon*

The southern DPS of North American green sturgeon historically was smaller than the sympatric population of white sturgeon in the San Francisco Bay estuary and its associated tributaries. The population has apparently been declining over the past several decades based on harvest numbers from sport and commercial fisheries and the entrainment rates at the CVP and SWP. The principle factor for this decline is the reduction of green sturgeon spawning habitat to a limited area below Keswick Dam on the Sacramento River. The construction of impassable barriers, particularly large dams, has greatly reduced the access of green sturgeon to their historical spawning areas. These barriers and their manipulation of the normal hydrograph for the river also have had detrimental effects on the natural life history of green sturgeon. Reduced flows have corresponded with weakened year class recruitment in the sympatric white sturgeon population and it is believed to have the same effect upon green sturgeon recruitment. Obstruction of natural sedmiment recruitment below large impoundments potentially has increased predation on larval and juvenile sturgeon due to a reduction in turbidity and loss of larger diameter substrate. In addition to the adverse effects of impassable barriers, numerous agricultural water diversions exist in the Sacramento River and the Delta along the migratory route of larval and juvenile sturgeon. Entrainment, or, if equipped with a fish screen, impingement are considered serious threats to sturgeon during their downstream migration. Fish screens have not been designed with criteria that address sturgeon behavior or swimming capabilities. The benthic oriented sturgeon are also more susceptible to contaminated sediments through dermal contact and through their feeding behavior of ingesting prey along with contaminated sediments before winnowing out the sediment. Their long life spans allow them to accumulate high body burdens of contaminants, that potentially will reach concentrations with deleterious physiological effects.

C. Habitat Condition and Function for Species' Conservation

The freshwater habitat of salmon, steelhead, and sturgeon in the Sacramento River, San Joaquin River, and Suisun Marsh watershed drainages varies in function depending on location. Spawning areas are located in accessible, upstream reaches of the Sacramento or San Joaquin Rivers and their watersheds where viable spawning gravels and water quality are found. Spawning habitat condition is strongly affected by water flow and quality, especially temperature, DO, and silt load, all of which can greatly affect the survival of eggs and larvae. High quality spawning habitat is now inaccessible behind large dams in these watersheds, which limits salmonids to spawning in marginal tailwater habitat below the dams. Despite often intensive management efforts, the existing spawning habitat below dams is highly susceptible to inadequate flows and high temperatures due to competing demands for water, which impairs the habitat function.

Migratory corridors are downstream of the spawning area and include the Delta and Suisun Marsh. These corridors allow the upstream passage of adults and the downstream emigration of juveniles. Migratory habitat conditions are impaired in each of these drainages by the presence of barriers, which can include dams, unscreened or poorly-screened diversions, inadequate water flows, and degraded water quality.

Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing by salmonids, but such use has not been documented for sturgeon. Rearing habitat condition is strongly affected by habitat complexity, food supply, and presence of predators of juvenile salmonids and sturgeon. Some complex, productive habitats with floodplains remain in the Sacramento and San Joaquin River systems (*e.g.*, the lower Cosumnes River, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa) and the Yolo and Sutter bypasses). However, the channelized, leveed, and rip-rapped river reaches and sloughs that are common in the Delta and Suisun Marsh systems typically have lower habitat complexity, lower abundance of food organisms, and offer little protection from either fish or avian predators.

IV. ENVIRONMENTAL BASELINE

A. Factors Affecting the Species and Habitat

A number of documents have addressed the history of human activities, present environmental conditions, and factors contributing to the decline of salmon and steelhead species in the Central Valley and Suisun Marsh. For example, NMFS prepared range-wide status reviews for West coast Chinook salmon (Myers *et al.* 1998), steelhead (Busby *et al.* 1996) and green sturgon (Adams *et al.* 2002, NMFS 2005). Also, the NMFS BRT published a draft updated status review for West coast Chinook salmon and steelhead in November 2003 (NMFS 2003) and a final review in June 2005 (Good *et al.* 2005). Information also is available in Federal Register notices announcing ESA listing proposals and determinations for some of these species and their critical habitat (*e.g.*, 58 FR 33212, 59 FR 440, 62 FR 24588, 62 FR 43937, 63 FR 13347, 64 FR 24049, 64 FR 50394, 65 FR 7764). The Final Programmatic Environmental Impact Statement/Report (EIS/EIR) for the CALFED Bay-Delta Program (CALFED 1999), and the Final Programmatic EIS for the CVPIA (Department of Interior (DOI) 1999), provide an excellent summary of historical and recent environmental conditions for salmon and steelhead in the Central Valley.

The following general description of the factors affecting Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, North American green sturgeon, and their habitat is based on a summary of these documents.

In general, the human activities that have affected the listed anadromous salmonids and their habitats consist of: (1) dam construction that blocks previously accessible habitat; (2) water development and management activities that affect water quantity, flow timing, quality, and stream function; (3) land use activities such as agriculture, flood control, urban development, mining, road construction, and logging that degrade aquatic and riparian habitat; (4) hatchery operation and practices; (5) harvest activities; and (6) ecosystem restoration actions.

1. Habitat Blockage

Hydropower, flood control, and water supply dams of the CVP, SWP, and other municipal and private entities have permanently blocked or hindered salmonid access to historical spawning and rearing grounds. Clark (1929) estimated that originally there were 6,000 linear miles of salmon habitat in the Central Valley system and that 80 percent of this habitat had been lost by 1928. Yoshiyama *et al.* (1996) calculated that roughly 2,000 linear miles of salmon habitat was actually available before dam construction and mining, and concluded that 82 percent is not accessible today.

In general, large dams on every major tributary to the Sacramento River, San Joaquin River, and the Delta block salmon and steelhead access to the upper portions of the respective watersheds. On the Sacramento River, Keswick Dam blocks passage to historic spawning and rearing habitat in the upper Sacramento, McCloud, and Pit Rivers. Whiskeytown Dam blocks access to the upper watershed of Clear Creek. Oroville Dam and associated facilities block passage to the upper Feather River watershed. Nimbus Dam blocks access to most of the American River basin. Friant Dam construction in the mid-1940s has been associated with the elimination of spring-run Chinook salmon in the San Joaquin River upstream of the Merced River (DOI 1999). On the Stanislaus River, construction of Goodwin Dam (1912), Tulloch Dam (1957), and New Melones Dam (1979) blocked both spring- and fall-run Chinook salmon (CDFG 2001) as well as Central Valley steelhead. Similarly, La Grange Dam (1893) and New Don Pedro Dam (1971) blocked upstream access to salmonids on the Tuolumne River. Upstream migration on the Merced River was blocked in 1910 by the construction of Merced Falls and Crocker-Huffman Dams and later New Exchequer Dam (1967) and McSwain Dam (1967). These dams also had the potential to block any spawning populations of green sturgeon in these tributaries.

As a result of the dams, winter-run Chinook salmon, spring-run Chinook salmon, and steelhead populations on these rivers have been confined to lower elevation mainstems that historically only were used for migration. Population abundances have declined in these streams due to decreased quantity and quality of spawning and rearing habitat. Higher temperatures at these lower elevations during late-summer and fall are a major stressor to adults and juvenile salmonids. Green sturgeon populations would be similarly affected by these barriers and alterations to the natural hydrology.

The Suisun Marsh Salinity Control Gates (SMSCG), located on Montezuma Slough, were installed in 1988, and are operated with gates and flashboards to decrease the salinity levels of managed wetlands in Suisun Marsh. The SMSCG have delayed or blocked passage of adult Chinook salmon migrating upstream (Edwards *et al.* 1996, Tillman *et al.* 1996, California

Department of Water Resources (DWR) 2002). The effects of the SMSCG on sturgeon is unknown at this time.

2. Water Development

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted streamflows and altered the natural cycles by which juvenile and adult salmonids base their migrations. As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta have been diverted for human uses. Depleted flows have contributed to higher temperatures, lower DO levels, and decreased recruitment of gravel and large woody debris (LWD). More uniform flows year round have resulted in diminished natural channel formation, altered foodweb processes, and slower regeneration of riparian vegetation. These stable flow patterns have reduced bedload movement (Mount 1995, Ayers 2001), caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the available spawning and rearing habitat below dams.

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Hundreds of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, and their tributaries. Although efforts have been made in recent years to screen some of these diversions, many remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile salmonids. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001). Most of the 370 water diversions operating in Suisun Marsh are unscreened (FWS 2003b).

Outmigrant juvenile salmonids in the Delta have been subjected to adverse environmental conditions created by water export operations at the CVP/SWP. Specifically, juvenile salmonid survival has been reduced by the following: (1) water diversion from the mainstem Sacramento River into the Central Delta via the Delta Cross Channel; (2) upstream or reverse flows of water in the lower San Joaquin River and southern Delta waterways; (3) entrainment at the CVP/SWP export facilities and associated problems at Clifton Court Forebay; and (4) increased exposure to introduced, non-native predators such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and sunfishes (*Centrarchidae* spp.).

3. Land Use Activities

Land use activities continue to have large impacts on salmonid habitat in the Central Valley watershed. Until about 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation extending outward for 4 or 5 miles (California Resources Agency 1989). By 1979, riparian habitat along the Sacramento River diminished to 11,000 to 12,000 acres, or about 2 percent of historic levels (McGill 1987). The degradation and fragmentation of riparian habitat had resulted mainly from flood control and bank protection projects, together with the conversion of riparian land to agriculture. Removal of snags and driftwood in the Sacramento and San Joaquin River basins has reduced sources of LWD needed to form and maintain stream habitat that salmon depend on in their various life stages.

Increased sedimentation resulting from agricultural and urban practices within the Central Valley is one of the primary causes of salmonid habitat degradation (NMFS 1996). Sedimentation can adversely affect salmonids during all freshwater life stages by: clogging or abrading gill surfaces, adhering to eggs, hampering fry emergence (Phillips and Campbell 1961), burying eggs or alevins, scouring and filling in pools and riffles, reducing primary productivity and photosynthesis activity (Cordone and Kelley 1961), and affecting intergravel permeability and DO levels. Excessive sedimentation over time can cause substrates to become embedded, which reduces successful salmonid spawning and egg and fry survival (Waters 1995).

Land use activities associated with road construction, urban development, logging, mining, agriculture, and recreation have significantly altered fish habitat quantity and quality through the alteration of streambank and channel morphology; alteration of ambient water temperatures; degradation of water quality; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of LWD; and removal of riparian vegetation, resulting in increased streambank erosion (Meehan 1991). Urban stormwater and agricultural runoff may be contaminated with herbicides and pesticides, petroleum products, sediment, *etc.* Agricultural practices in the Central Valley have eliminated large trees and logs and other woody debris that would otherwise be recruited into the stream channel (NMFS 1998). LWD influences stream morphology by affecting channel pattern, position, and geometry, as well as pool formation (Keller and Swanson 1979, Bilby 1984, Robison and Beschta 1990).

Since the 1850s, wetlands reclamation for urban and agricultural development has caused the cumulative loss of 79 and 94 percent of the tidal marsh habitat in the Delta downstream and upstream of Chipps Island, respectively (Conomos *et al.* 1985, Nichols *et al.* 1986, Wright and Phillips 1988, Monroe *et al.* 1992, Goals Project 1999). Prior to 1850, approximately 1400 km^2 of freshwater marsh surrounded the confluence of the Sacramento and San Joaquin Rivers, and another 800 km^2 of saltwater marsh fringed San Francisco Bay's margins. Of the original 2,200 km^2 of tidally influenced marsh, only about 125 km^2 of undiked marsh remains today. In Suisun Marsh, saltwater intrusion and land subsidence gradually has led to the decline of agricultural production. Presently, Suisun Marsh consists largely of tidal sloughs and managed wetlands for duck clubs, which first were established in the 1870s in western Suisun Marsh (Goals Project 1999).

Dredging of river channels to enhance inland maritime trade and to provide raw material for levee construction has significantly and detrimentally altered the natural hydrology and function of the river systems in the Central Valley. Starting in the mid-1800s, the Corps and other private consortiums began straightening river channels and artificially deepening them to enhance shipping commerce. This has led to declines in the natural meandering of river channels and the formation of pool and riffle segments. The deepening of channels beyond their natural depth also has led to a significant alteration in the transport of bedload in the riverine system as well as the local flow velocity in the channel (Mount 1995). The Sacramento Flood Control Project at the turn of the nineteenth century ushered in the start of large scale Corps actions in the Delta and along the rivers of California for reclamation and flood control. The creation of levees and the deep shipping channels reduced the natural tendency of the San Joaquin and Sacramento Rivers to create floodplains along their banks with seasonal inundations during the wet winter season and the spring snow melt periods. These annual inundations provided necessary habitat for rearing and foraging of juvenile native fish that evolved with this flooding process. The armored riprapped levee banks and active maintenance actions of Reclamation Districts precluded the establishment of ecologically important riparian vegetation, introduction of valuable LWD from these riparian corridors, and the productive intertidal mudflats characteristic of the undisturbed Delta habitat.

Juvenile salmonids are exposed to increased water temperatures in the Delta during the late spring and summer due to the loss of riparian shading, and by thermal inputs from municipal, industrial, and agricultural discharges. Studies by DWR on water quality in the Delta over the last 30 years show a steady decline in the food sources available for juvenile salmonids and sturgeon and an increase in the clarity of the water due to a reduction in phytoplankton and zooplankton. These conditions have contributed to increased mortality of juvenile Chinook salmon, steelhead, and sturgeon as they move through the Delta.

4. Water Quality

The water quality of the Delta has been negatively impacted over the last 150 years. Increased water temperatures, decreased DO levels, and increased turbidity and contaminant loads have degraded the quality of the aquatic habitat for the rearing and migration of salmonids. The Regional Board, in its 1998 Clean Water Act §303(d) list characterized the Delta as an impaired waterbody having elevated levels of chlorpyrifos, dichlorodiphenyltrichlor (*i.e.* DDT), diazinon, electrical conductivity, Group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane (including lindane), endosulfan and toxaphene), mercury, low DO, organic enrichment, and unknown toxicities (Regional Board 1998, 2001).

In general, water degradation or contamination can lead to either acute toxicity, resulting in death when concentrations are sufficiently elevated, or more typically, when concentrations are lower, to chronic or sublethal effects that reduce the physical health of the organism, and lessens its survival over an extended period of time. Mortality may become a secondary effect due to compromised physiology or behavioral changes that lessen the organism's ability to carry out its normal activities. For example, increased levels of heavy metals are detrimental to the health of an organism because they interfere with metabolic functions by inhibiting key enzyme activity in metabolic pathways, decrease neurological function, degrade cardiovascular output, and act as mutagens, teratogens or carcinogens in exposed organisms (Rand *et al.* 1995, Goyer 1996). For listed species, these effects may occur directly to the listed fish or to its prey base, which reduces the forage base available to the listed species.

Sediments can either act as a sink or as a source of contamination depending on hydrological conditions and the type of habitat the sediment occurs in. Sediment provides habitat for many aquatic organisms and is a major repository for many of the more persistent chemicals that are introduced into the surface waters. In the aquatic environment, most anthropogenic chemicals and waste materials including toxic organic and inorganic chemicals eventually accumulate in sediment (Ingersoll 1995).

Direct exposure to contaminated sediments may cause deleterious effects to listed salmonids or green sturgeon. This may occur if a fish swims through a plume of the resuspended sediments or rests on contaminated substrate and absorbs the toxic compounds through one of several routes: dermal contact, ingestion, or uptake across the gills. Elevated contaminant levels may be found in localized "hot spots" where discharge occurs or where river currents deposit sediment loads. Sediment contaminant levels can thus be significantly higher than the overlying water column concentrations (EPA 1994). However, the more likely route of exposure to salmonids or sturgeon is through the food chain, when the fish feed on organisms that are contaminated with toxic compounds. Prey species become contaminated either by feeding on the detritus associated with the sediments or dwelling in the sediment itself. Therefore, the degree of exposure to the salmonids depends on their trophic level and the amount of contaminated forage base they consume. Response of salmonids to contaminated sediments is similar to water borne exposures.

Low DO levels frequently are observed in the portion of the DWSC extending from Channel Point, downstream to Turner and Columbia Cuts. Over a 5-year period, starting in August 2000, a DO meter has recorded channel DO levels at Rough and Ready Island (Dock 20 of the West Complex). Over the course of this time period, there have been 297 days in which violations of the 5 mg/l DO criteria for the protection of aquatic life in the San Joaquin River between Channel Point and Turner and Columbia Cuts have occurred during the September through May migratory period for salmonids in the San Joaquin River. The data derived from the California Data Exchange Center files indicate that DO depressions occur during all migratory months, with significant events occurring from November through March when listed Central Valley steelhead adults and smolts would be utilizing this portion of the San Joaquin River as a migratory corridor (see Appendix A, Table 4).

Potential factors that contribute to these DO depressions are reduced river flows through the ship channel, released ammonia from the City of Stockton Wastewater Treatment Plant, upstream contributions of organic materials (*e.g.*, algal loads, nutrients, agricultural discharges) and the increased volume of the dredged ship channel. During the winter and early spring emigration period, increased ammonia concentrations in the discharges from the City of Stockton Waste Water Treatment Facility lowers the DO in the adjacent DWSC near the West Complex. In addition to the adverse effects of the lowered DO on salmonid physiology, ammonia is in itself toxic to salmonids at low concentrations. Likewise, adult fish migrating upstream will encounter lowered DO in the DWSC as they move upstream in the fall and early winter due to low flows and excessive algal and nutrient loads coming downstream from the upper San Joaquin River watershed. Levels of DO below 5 mg/L have been reported as delaying or blocking fall-run Chinook salmon in studies conducted by Hallock *et al.* (1970). As the river water and its constituents move downstream from the San Joaquin River channel to the DWSC, the channel depth increases from approximately 8 to 10 feet to over 35 feet. The water column is no longer mixed adequately to prevent DO from decreasing by contact with the air–water interface only. Photosynthesis by suspended algae is diminished by increased turbidity and circulation below the photosynthetic compensation depth. This is the depth to which light penetrates with adequate intensity to carry on photosynthesis in excess of the oxygen demands of respiration. As the oxygen demand from respiration, defined as biological oxygen demand, exceeds the rate at which oxygen can be produced by photosynthesis and mixing, then the level of DO in the water column will decrease. Additional demands on oxygen are also exerted in non-biological chemical reactions in which compounds consume oxygen in an oxidation-reduction reaction.

5. Hatchery Operations and Practices

Five hatcheries currently produce Chinook salmon in the Central Valley and four of these also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to wild Chinook salmon and steelhead stocks through genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). The genetic impacts of artificial propagation programs in the Central Valley primarily are caused by straying of hatchery fish and the subsequent interbreeding of hatchery fish with wild fish. In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels (DOI 1999). For example, Nimbus Hatchery on the American River rears Eel River steelhead stock and releases these fish in the Sacramento River basin. One of the recommendations in the Joint Hatchery Review Report (NMFS and CDFG 2001) was to identify and designate new sources of steelhead brood stock to replace the current Eel River origin brood stock.

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between spring- and fall-run fish have led to the hybridization and homogenization of some subpopulations (CDFG 1998). As early as the 1960s, Slater (1963) observed that early fall- and spring-run Chinook salmon were competing for spawning sites in the Sacramento River below Keswick Dam, and speculated that the two runs may have hybridized. The FRH spring-run Chinook salmon have been documented as straying throughout the Central Valley for many years (CDFG 1998), and in many cases have been recovered from the spawning grounds of fall-run Chinook salmon, an indication that FRH spring-run Chinook salmon may exhibit fall-run life history characteristics. Although the degree of hybridization has not been comprehensively determined, it is clear that the populations of spring-run Chinook salmon spawning in the Feather River and counted at RBDD contain hybridized fish.

The management of hatcheries, such as Nimbus Hatchery and FRH, can directly impact spring-run Chinook salmon and steelhead populations by oversaturating the natural carrying capacity of the limited habitat available below dams. In the case of the Feather River, significant redd superimposition occurs in-river due to hatchery overproduction and the inability to physically separate spring- and fall-run Chinook salmon adults. This concurrent spawning has led to hybridization between the spring- and fall-run Chinook salmon in the Feather River. At Nimbus Hatchery, operating Folsom Dam to meet temperature requirements for returning hatchery fall-run Chinook salmon often limits the amount if water available for steelhead spawning and rearing the rest of the year.

The increase in Central Valley hatchery production has reversed the composition of the steelhead population, from 88 percent naturally-produced fish in the 1950s (McEwan 2001) to an estimated 23 to 37 percent naturally-produced fish currently (Nobriga and Cadrett 2001). The increase in hatchery steelhead production proportionate to the wild population has reduced the viability of the wild steelhead populations, increased the use of out-of-basin stocks for hatchery production, and increased straying (NMFS and CDFG 2001). Thus, the ability of natural populations to successfully reproduce and continue their genetic integrity likely has been diminished.

The relatively low number of spawners needed to sustain a hatchery population can result in high harvest-to-escapements ratios in waters where fishing regulations are set according to hatchery population. This can lead to over-exploitation and reduction in the size of wild populations existing in the same system as hatchery populations due to incidental bycatch (McEwan 2001).

Hatcheries also can have some positive effects on salmonid populations. Artificial propagation has been shown to be effective in bolstering the numbers of naturally spawning fish in the short term under specific scenarios, artificial propagation programs can also aid in conserving genetic resources and guarding against catastrophic loss of naturally spawned populations at critically low abundance levels, as was the case with the Sacramento River winter-run Chinook salmon population during the 1990s. However, relative abundance is only one component of a viable salmonid population.

6. Commercial and Sport Harvest

a. *Ocean Harvest*

(1) *Chinook salmon*. Extensive ocean recreational and commercial troll fisheries for Chinook salmon exist along the Central California coast, and an inland recreational fishery exists in the Central Valley for Chinook salmon and steelhead. Ocean harvest of Central Valley Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught) to escapement. CWT returns indicate that Sacramento River salmon congregate off the California coast between Point Arena and Morro Bay.

Since 1970, the CVI for winter-run Chinook salmon generally has ranged between 0.50 and 0.80. In 1990, when ocean harvest of winter-run Chinook salmon was first evaluated by NMFS and the Pacific Fisheries Management Council (PFMC), the CVI harvest rate was near the highest recorded level at 0.79. NMFS determined in a 1991 biological opinion that continuance of the 1990 ocean harvest rate would not prevent the recovery of winter-run Chinook salmon. Through the early 1990s, the ocean harvest index was below the 1990 level (*i.e.*, 0.71 in 1991 and 1992, 0.72 in 1993, 0.74 in 1994, 0.78 in 1995, and 0.64 in 1996). In 1996 and 1997, NMFS issued a biological opinion which concluded that incidental ocean harvest of winter-run Chinook salmon represented a significant source of mortality to the endangered population, even though ocean harvest was not a key factor leading to the decline of the population. As a result of these opinions, measures were developed and implemented by the PFMC, NMFS, and CDFG to reduce ocean harvest by approximately 50 percent.

Ocean fisheries have affected the age structure of spring-run Chinook salmon through targeting large fish for many years and reducing the numbers of 4- and 5-year-old fish (CDFG 1998). There are limited data on spring-run Chinook salmon ocean harvest rates. An analysis of 6 tagged groups of FRH spring-run Chinook salmon by Cramer and Demko (1997) indicated that harvest rates of 3-year-old fish ranged from 18 percent to 22 percent, 4-year-old fish ranged from 57 percent to 84 percent, and 5-year-olds ranged from 97 percent to 100 percent. The almost complete removal of 5-year-olds from the population effectively reduces the age structure of the species, which reduces its resiliency to factors that may impact a particular year class (*e.g.*, pre-spawning mortality from lethal instream water temperatures).

(2) ***Green sturgeon***. Ocean harvest for green sturgeon occurs primarily along the Oregon and Washington coasts and within their coastal estuaries. A commercial fishery for sturgeon still exists within the Columbia River, where they are caught in gill nets along with the more commercially valuable white sturgeon. Green sturgeons are also caught by recreational fisherman, and it is the primary bottomfish landed in Willapa Bay. Within the San Francisco Bay estuary, green sturgeons are captured by sport fisherman targeting the more desirable white sturgeon, particularly in San Pablo and Suisun Bays (Emmett *et al.* 1991).

b. *Freshwater Sport Harvest*

(1) ***Chinook salmon.*** Historically in California, almost half of the river sportfishing effort was in the Sacramento-San Joaquin River system, particularly upstream from the city of Sacramento (Emmett *et al.* 1991). Since 1987, the Fish and Game Commission has adopted increasingly stringent regulations to reduce and virtually eliminate the in-river sport fishery for winter-run Chinook salmon. Present regulations include a year-round closure to Chinook salmon fishing between Keswick Dam and the Deschutes Road Bridge and a rolling closure to Chinook salmon fishing on the Sacramento River between the Deschutes River Bridge and the Carquinez Bridge. The rolling closure spans the months that migrating adult winter-run Chinook salmon are ascending the Sacramento River to their spawning grounds. These closures have virtually eliminated impacts on winter-run Chinook salmon caused by recreational angling in freshwater.

In 1992, the California Fish and Game Commission adopted gear restrictions (all hooks must be barbless and a maximum of 5.7 cm in length) to minimize hooking injury and mortality of winter-run Chinook salmon caused by trout anglers. That same year, the Commission also adopted regulations which prohibited any salmon from being removed from the water to further reduce the potential for injury and mortality.

In-river recreational fisheries historically have taken spring-run Chinook salmon throughout the species' range. During the summer, holding adult spring-run Chinook salmon are easily targeted by anglers when they congregate in large pools. Poaching also occurs at fish ladders, and other areas where adults congregate; however, the significance of poaching on the adult population is unknown. Specific regulations for the protection of spring-run Chinook salmon in Mill, Deer, Butte and Big Chico creeks were added to the existing CDFG regulations in 1994. The current regulations, including those developed for winter-run Chinook salmon, provide some level of protection for spring-run fish (CDFG 1998).

(2) *Steelhead*. There is little information on steelhead harvest rates in California. Hallock *et al.* (1961) estimated that harvest rates for Sacramento River steelhead from the 1953-1954 through 1958-1959 seasons ranged from 25.1 percent to 45.6 percent assuming a 20 percent non-return rate of tags. Staley (1975) estimated the harvest rate in the American River during the 1971-1972 and 1973-1974 seasons to be 27 percent. The average annual harvest rate of adult steelhead above RBDD for the 3-year period from 1991-1992 through 1993-1994 was 16 percent (McEwan and Jackson 1996). Since 1998, all hatchery steelhead have been marked with an adipose fin clip allowing anglers to distinguish hatchery and wild steelhead. Current regulations restrict anglers from keeping unmarked steelhead in Central Valley streams (CDFG 2004c). Overall, this regulation has greatly increased protection of naturally produced adult steelhead.

(3) Green sturgeon. Green sturgeon are caught incidentally by sport fisherman targeting the more highly desired white sturgeon within the Delta waterways and the Sacramento River. Due to slot limits imposed on the sport fishery by the California DFG, only sturgeon between 46 and 72 inches may be retained by sport fisherman with a daily bag limit of 1 fish in possession. This protects both fish that are sexually immature and have not yet had an opportunity to spawn, and those larger females that have the greatest reproductive value to the population.

7. <u>Predation</u>

Accelerated predation also may be a factor in the decline of winter-run Chinook salmon and spring-run Chinook salmon, and to a lesser degree steelhead. Human-induced habitat changes such as alteration of natural flow regimes and installation of bank revetment and structures such as dams, bridges, water diversions, piers, and wharves often provide conditions that both disorient juvenile salmonids and attract predators (Stevens 1961, Decato 1978, Vogel *et al.* 1988, Garcia 1989).

On the mainstem Sacramento River, high rates of predation are known to occur at the RBDD, Anderson Cottonwood Irrigation District's diversion dam, GCID's diversion dam, areas where rock revetment has replaced natural riverbank vegetation, and at south Delta water diversion structures (*e.g.*, Clifton Court Forebay; CDFG 1998). Predation at RBDD on juvenile winter-run Chinook salmon is believed to be higher than normal due to factors such as water quality and flow dynamics associated with the operation of this structure. Due to their small size, early emigrating winter-run Chinook salmon may be very susceptible to predation in Lake Red Bluff when the RBDD gates remain closed in summer and early fall (Vogel *et al.* 1988). In passing the dam, juveniles are subject to conditions which greatly disorient them, making them highly susceptible to predation by fish or birds. Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass congregate below the dam and prey on juvenile salmon in the tail waters.

FWS found that more predatory fish were found at rock revetment bank protection sites between Chico Landing and Red Bluff than at sites with naturally eroding banks (Michny and Hampton 1984). From October 1976 to November 1993, CDFG conducted 10 mark/recapture studies at the SWP's Clifton Court Forebay to estimate pre-screen losses using hatchery-reared juvenile Chinook salmon. Pre-screen losses ranged from 69 percent to 99 percent. Predation by striped bass is thought to be the primary cause of the loss (Gingras 1997).

Other locations in the Central Valley where predation is of concern include flood bypasses, post-release sites for salmonids salvaged at the State and Federal fish facilities, and the SMSCG. Predation on salmon by striped bass and pikeminnow at salvage release sites in the Delta and lower Sacramento River has been documented (Orsi 1967, Pickard *et al.* 1982); however, accurate predation rates at these sites are difficult to determine. CDFG conducted predation studies from 1987to 1993 at the SMSCG to determine if the structure attracts and concentrates predators. The dominant predator species at the SMSCG was striped bass, and the remains of juvenile Chinook salmon were identified in their stomach contents (NMFS 1997).

8. <u>Environmental Variation</u>

Natural changes in the freshwater and marine environments play a major role in salmonid abundance. Recent evidence suggests that marine survival among salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hare *et al.* 1999, Mantua and Hare 2002). This phenomenon has been referred to as the Pacific Decadal Oscillation. In addition, large-scale climatic regime shifts, such as the El Niño condition, appear to change productivity levels over large expanses of the Pacific Ocean. A further confounding effect is the fluctuation between drought and wet conditions in the basins of the American west. During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years, which reduced inflows to watersheds up and down the west coast.

A key factor affecting many West Coast stocks has been a general 30-year decline in ocean productivity. The mechanism whereby stocks are affected is not well understood, partially because the pattern of response to these changing ocean conditions has differed among stocks, presumably due to differences in their ocean timing and distribution. It is presumed that survival in the ocean is driven largely by events occurring between ocean entry and recruitment to a subadult life stage.

Salmon and steelhead are exposed to high rates of natural predation, particularly during freshwater rearing and migration stages. Predation rates on juvenile and adult green sturgeon have not been adequately studied to date. Ocean predation may also contribute to significant natural mortality, although it is not known to what extent. In general, salmonids are prey for pelagic fishes, birds, and marine mammals, including harbor seals, sea lions, and killer whales. There have been recent concerns that the rebound of seal and sea lion populations following their protection under the Marine Mammal Protection Act of 1972 has increased the number of salmonid deaths. This may be further exacerbated by the decline of other fisheries stocks (*i.e.* haddock, Pollock, and members of the genus *Sebastes*) which provided alternative forage resources to marine mammals.

Finally, unusual drought conditions may warrant additional consideration in California. Flows in 2001 were among the lowest flow conditions on record in the Central Valley. The available water in the Sacramento watershed and San Joaquin watershed was 70 percent and 66 percent of normal, according to the Sacramento River Index and the San Joaquin River Index, respectively. Back-to-back drought years could be catastrophic to small populations of listed salmonids that are dependent upon reservoir releases for their success (*e.g.*, winter-run Chinook salmon). Therefore, reservoir carryover storage (usually referred to as end-of-September storage) is a key element in providing adequate reserves to protect salmon and steelhead during extended drought periods. In order to buffer the effect of drought conditions and over allocation of resources, NMFS in the past has recommended that minimum carryover storage be maintained in Shasta and other reservoirs to help alleviate critical flow and temperature conditions in the fall. Green sturgeon's need for appropriate water temperatures would also benefit from river operations that maintain a suitable temperature profile for this species.

The future effects of global warming are of key interest to salmonid and green sturgeon survival. It is predicted that Sierra snow packs will dwindle with global warming and that the majority of runoff in California will be from rainfall in the winter rather than from melting snow pack in the mountains. This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. It can be rationally hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This should truncate the period of time that suitable cold water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids (*i.e.* winter-run Chinook salmon and Central Valley steelhead) that must hold below the dam over the summer and fall periods. Similar, although potentially to a lesser degree, declines in green sturgeon populations are anticipated with reduced cold water flows. Green sturgeon egg and larval development are optimized at water temperatures that are only slightly higher than those for salmonids. Lethal temperatures are similar to salmonids, although slightly higher than those for salmonids.

9. <u>Ecosystem Restoration</u>

a. *California Bay-Delta Authority*

Two programs included under California Bay Delta Authority (CBDA); the Ecosystem Restoration Program (ERP) and the EWA, were created to improve conditions for fish, including listed salmonids, in the Central Valley. Restoration actions implemented by the ERP include the installation of fish screens, modification of barriers to improve fish passage, habitat acquisition, and instream habitat restoration. The majority of these actions address key factors affecting listed salmonids and emphasis has been placed in tributary drainages with high potential for steelhead and spring-run Chinook salmon production. Additional ongoing actions include new efforts to enhance fisheries monitoring and directly support salmonid production through hatchery releases. Recent habitat restoration initiatives sponsored and funded primarily by the CBDA-ERP Program have resulted in plans to restore ecological function to 9,543 acres of shallow-water tidal and marsh habitats within the Delta. Restoration of these areas primarily involves flooding lands previously used for agriculture, thereby creating additional rearing habitat for juvenile salmonids. Similar habitat restoration is imminent adjacent to Suisun Marsh (*i.e.*, at the confluence of Montezuma Slough and the Sacramento River) as part of the Montezuma Wetlands project, which is intended to provide for commercial disposal of material dredged from San Francisco Bay in conjunction with tidal wetland restoration.

A sub-program of the ERP called the Environmental Water Program (EWP) has been established to support ERP projects through enhancement of instream flows that are biologically and ecologically significant. This program is in the development stage and the benefits to listed salmonids are not yet clear. Clear Creek is one of five watersheds in the Central Valley that has been targeted for action during Phase I of the EWP.

The EWA is designed to provide water at critical times to meet ESA requirements and incidental take limits without water supply impacts to other users. In early 2001, the EWA released 290 thousand acre feet of water from San Luis Reservoir at key times to offset reductions in south Delta pumping implemented to protect winter-run Chinook salmon, delta smelt, and splittail. However, the benefit derived by this action to winter-run Chinook salmon in terms of number of fish saved was very small. The anticipated benefits to other Delta fisheries from the use of the EWA water are much higher than those benefits ascribed to listed salmonids by the EWA release.

b. *Central Valley Project Improvement Act*

The CVPIA, implemented in 1992, requires that fish and wildlife get equal consideration with other demands for water allocations derived from the CVP. From this act arose several programs that have benefited listed salmonids: the Anadromous Fish Restoration Program (AFRP), the Anadromous Fish Screen Program (AFSP), and the Water Acquisition Program (WAP). The AFRP is engaged in monitoring, education, and restoration projects geared toward recovery of all anadromous fish species residing in the Central Valley. Restoration projects funded through the AFRP include fish passage, fish screening, riparian easement and land acquisition, development of watershed planning groups, instream and riparian habitat improvement, and gravel replenishment. The AFSP combines Federal funding with State and private funds to prioritize and construct fish screens on major water diversions mainly in the upper Sacramento River. The goal of the WAP is to acquire water supplies to meet the habitat restoration and enhancement goals of the CVPIA and to improve the DOI's ability to meet regulatory water quality requirements. Water has been used successfully to improve fish habitat for spring-run Chinook salmon and steelhead by maintaining or increasing instream flows in Butte and Mill Creeks and the San Joaquin River at critical times.

c. *Iron Mountain Mine Remediation*

EPA's Iron Mountain Mine remediation involves the removal of toxic metals in acidic mine drainage from the Spring Creek Watershed with a state-of-the-art lime neutralization plant. Contaminant loading into the Sacramento River from Iron Mountain Mine has shown measurable reductions since the early 1990s (see Appendix J, Reclamation 2004). Decreasing the heavy metal contaminants that enter the Sacramento River should increase the survival of salmonid eggs and juveniles. However, during periods of heavy rainfall upstream of the Iron Mountain Mine, Reclamation substantially increases Sacramento River flows in order to dilute heavy metal contaminants being spilled from the Spring Creek debris dam. This rapid change in flows can cause juvenile salmonids to become stranded or isolated in side channels below Keswick Dam.

d. *State Water Project Delta Pumping Plant Fish Protection Agreement (Four-Pumps Agreement)*

The Four Pumps Agreement Program has approved about $49 million for projects that benefit salmon and steelhead production in the Sacramento-San Joaquin basins and Delta since the agreement inception in 1986. Four Pumps projects that benefit spring-run Chinook salmon and steelhead include water exchange programs on Mill and Deer Creeks; enhanced law enforcement efforts from San Francisco Bay upstream to the Sacramento and San Joaquin Rivers and their tributaries; design and construction of fish screens and ladders on Butte Creek; and screening of diversions in Suisun Marsh and San Joaquin tributaries. Predator habitat isolation and removal, and spawning habitat enhancement projects on the San Joaquin tributaries benefit steelhead (see Chapter 15, Reclamation 2004).

The Spring-run Salmon Increased Protection Project provides overtime wages for CDFG wardens to focus on reducing illegal take and illegal water diversions on upper Sacramento River tributaries and adult holding areas, where the fish are vulnerable to poaching. This project covers Mill, Deer, Antelope, Butte, Big Chico, Cottonwood, and Battle Creeks, and has been in effect since 1996. Through the Delta-Bay Enhanced Enforcement Program, initiated in 1994, a team of 10 wardens focus their enforcement efforts on salmon, steelhead, and other species of concern from the San Francisco Bay Estuary upstream into the Sacramento and San Joaquin River basins. These two enhanced enforcement programs have had significant, but unquantified benefits; to spring-run Chinook salmon attributed by CDFG (see Chapter 15, Reclamation 2004).

The Mill and Deer Creek Water Exchange projects are designed to provide new wells that enable diverters to bank groundwater in place of stream flow, thus leaving water in the stream during critical migration periods. On Mill Creek several agreements between Los Molinos Mutual Water Company (LMMWC), Orange Cove Irrigation District (OCID), CDFG, and DWR allows DWR to pump groundwater from two wells into the LMMWC canals to pay back LMMWC water rights for surface water released downstream for fish. Although the Mill Creek Water Exchange project was initiated in 1990 and the agreement allows for a well capacity of 25 cfs, only 12 cfs has been developed to date (Reclamation and OCID 1999). In addition, it has been determined that a base flow of greater than 25 cfs is needed during the April through June period for upstream passage of adult spring-run Chinook salmon in Mill Creek (Reclamation and OCID 1999). In some years, water diversions from the creek are curtailed by amounts sufficient to provide for passage of upstream migrating adult spring-run Chinook salmon and downstream migrating juvenile steelhead and spring-run Chinook salmon. However, the current arrangement does not ensure adequate flow conditions will be maintained in all years. DWR, CDFG, and FWS have developed the Mill Creek Adaptive Management Enhancement Plan to address the instream flow issues. A pilot project using 1 of the 10 pumps originally proposed for Deer Creek was tested in summer 2003. Future testing is planned with implementation to follow.

10. Non-native Invasive Species

As currently seen in the San Francisco estuary, non-native invasive species (NIS) can alter the natural food webs that existed prior to their introduction. Perhaps the most significant example is illustrated by the Asiatic freshwater clams *Corbicula fluminea* and *Potamocorbula amurensis*. The arrival of these clams in the estuary disrupted the normal benthic community structure and depressed phytoplankton levels in the estuary due to the highly efficient filter feeding of the introduced clams (Cohen and Moyle 2004). The decline in the levels of phytoplankton reduces the population levels of zooplankton that feed upon them, and hence reduces the forage base available to salmonids transiting the Delta and San Francisco estuary which feed either upon the zooplankton directly or their mature forms. This lack of forage base can adversely impact the health and physiological condition of these salmonids as they emigrate through the Delta region to the Pacific Ocean.

Attempts to control the NIS also can adversely impact the health and well being of salmonids within the affected water systems. For example, the control programs for the invasive water hyacinth and *Egeria densa* plants in the Delta must balance the toxicity of the herbicides applied to control the plants to the probability of exposure to listed salmonids during herbicide application. In addition, the control of the nuisance plants have certain physical parameters that must be accounted for in the treatment protocols, particularly the decrease in DO resulting from the decomposing vegetable matter left by plants that have died.

11. Summary

For Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead, the construction of high dams for hydropower, flood control, and water supply resulted in the loss of vast amounts of upstream habitat (*i.e.*, approximately 80 percent, or a minimum linear estimate of over 1,000 stream miles), and often resulted in precipitous declines in affected salmonid populations. For example, the completion of Friant Dam in 1947 has been linked with the extirpation of spring-run Chinook salmon in the San Joaquin River upstream of the Merced River within just a few years. The reduced populations that remain below Central Valley dams are forced to spawn in lower elevation tailwater habitats of the mainstem rivers and tributaries that were previously not used for this purpose. This habitat is entirely dependent on managing reservoir releases to maintain cool water temperatures suitable for spawning, and/or rearing of salmonids. This requirement has been difficult to achieve in all water year types and for all life stages of affected salmonid species. Steelhead, in particular, seem to require the qualities of small tributary habitat similar to what they historically used for spawning; habitat that is largely unavailable to them under the current water management scenario. All salmonid species considered in this consultation have been adversely affected by the production of hatchery fish associated with the mitigation for the habitat lost to dam construction (*e.g.*, from genetic impacts, increased competition, exposure to novel diseases, *etc.*).

Land-use activities such as road construction, urban development, logging, mining, agriculture, and recreation are pervasive and have significantly altered fish habitat quantity and quality for Chinook salmon and steelhead through alteration of streambank and channel morphology; alteration of ambient water temperatures; degradation of water quality; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of LWD; and removal of riparian vegetation resulting in increased streambank erosion. Human-induced habitat changes, such as: alteration of natural flow regimes; installation of bank revetment; and building structures such as dams, bridges, water diversions, piers, and wharves, often provide conditions that both disorient juvenile salmonids and attract predators. Harvest activities, ocean productivity, and drought conditions provide added stressors to listed salmonid populations. In contrast, various ecosystem restoration activities have contributed to improved conditions for listed salmonids (*e.g.*, various fish screens). However, some important restoration activities (*e.g.*, Battle Creek) have not yet been initiated. Benefits to listed salmonids from the EWA have been smaller than anticipated.

Similar to the listed salmonids, the southern DPS of North American green sturgeon have been negatively impacted by hydroelectric and water storage operations in the Central Valley which ultimately affect the hydrology and accesibility of Central Valley rivers and streams to anadromous fish. Anthrpogenic manipulations of the aquatic habitat, such as dredging, bank stabilization, and waste water discharges have also degraded the quality of the Central Valley's waterways for green sturgeon.

B. Existing Monitoring Programs

Salmon-focused monitoring efforts are taking place throughout the Sacramento and San Joaquin River basins, and the Suisun Marsh. Many of these programs incidentally gather information on steelhead but a focused, comprehensive steelhead monitoring program has not been funded or implemented in the Central Valley. The existing salmonid monitoring efforts are summarized in Table 5 (Appendix A) by geographic area and target species. Information for this summary was derived from a variety of sources:

- 1999 IEP Steelhead Project Work Team report on monitoring, assessment, and research on steelhead: status of knowledge, review of existing programs, and assessment of needs (IEP 1999);
- CDFG Plan;
- U.S. Forest Service Sierra Nevada Framework monitoring plan;
- ESA section 10 and section 4(d) scientific research permit applications;
- Trinity River Restoration Program biological monitoring; and
- Suisun Marsh Monitoring Program.

Studies focused on the life history of green sturgeon are currently being implemented by researchers at academic institutions such as University of California. Davis. Future plans include radio-telemetry studies to track the movements of green sturgeon within the Delta and Sacramento River systems. Additional studies concerning the basic biology and physiology of the fish are also being conducted to better understand the fish's niche in the aquatic system.

C. Presence of Listed Salmonids in the Action Area

The action area for the EDCP essentially covers the legal Delta from Freeport on the Sacramento River to Sherman Island in the western Delta and south to Mossdale on the San Joaquin River. EDCP sites are more heavily concentrated in the central Delta and south Delta, but *Egeria densa* is pandemic in the Delta. All of the listed Central Valley steelhead in the San Joaquin River watershed originating from the Calaveras, Stanislaus, Tuolumne, or Merced Rivers will have to pass through the action area on both their downstream emigration to the ocean as smolts and on their upstream spawning migrations as adults. Those few adults that survive to spawn a second time would also pass through this portion of the river again. There is the potential for fish to make their way through either Old River or Middle River to access the upper San Joaquin watershed above the Head of Old River, but their success depends on whether or not the Head of Old River Barrier is in place. Smolts are more likely than adults to stay within the mainstem during their migrations, as they follow the prevailing current out to the ocean. Upstream migrating adults have the option of following either the Sacramento River or San Joaquin River upon their entry into the Delta. This co-mingling of water sources can result in milling behavior as fish seek out the olfactory cues of their natal stream.

Based on fish monitoring studies, Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead juveniles and smolts from the Sacramento River watershed frequently enter into the central Delta waterways and the San Joaquin River system based on river flows and SWP and CVP pumping rates. Fish from the Sacramento River can access the central Delta and the San Joaquin River from several points; the Delta Cross Channel via the North and South Forks of the Mokelumne River, Georgiana Slough, Three Mile Slough, and the mouth of the San Joaquin River near Antioch and Sherman Island. Fish entering into the Delta after the start of the EDCP would be exposed to the effects of this project while they migrated within the Delta's waterways. In addition, adults of these listed salmonids could potentially be exposed to the EDCP if they entered into the Delta during the application season on their upstream migrations.

D. Presence of Green Sturgeon in the Action Area

Although the Sacramento River watershed is the identified migration route and spawning area for green sturgeon, both adult and juvenile green sturgeon are known to occur within the lower reaches of the San Joaquin River and into the south Delta. Juveniles have been captured in the vicinity of Santa Clara Shoals, Brannan Island State Recreational Area and in the channels of the south Delta (Moyle *et al.* 1992, Beamesderfer *et al.* 2004). Green sturgeon also have been recovered at both the SWP and CVP pumping facilities on Old River near Tracy, indicating that they must have transited through one of the many channels of the south Delta to reach that location. Both adult and juvenile green sturgeon may use the Delta as a migratory, resting, or rearing habitat. Occurrence in the Delta could occur in any month, as juveniles may reside there during their first few years of growth. Adults are likely to be present in the winter and early spring as they move through the Delta towards their spawning grounds in the upper Sacramento River watershed. Following spawning, the fish will pass through the Delta again on their way back to the ocean, but the duration and timing of this event is not well understood in the Sacramento River system.

V. EFFECTS OF THE ACTION

Pursuant to section 7(a)(2) of the Endangered Species Act (ESA) (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. This biological opinion assesses the effects of the EDCP on the endangered Sacramento winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon ESUs and threatened Central Valley steelhead DPS. The biological opinion also assesses the effects of the EDCP upon the critical habitat of these two Chinook salmon ESUs and the one steelhead DPS. The EDCP is likely to adversely affect listed species and critical habitat through application of herbicides to waters of the Delta and the resulting short-term alterations in the natural environment. In the *Description of the Proposed Action* section of this Opinion, NMFS (NMFS) provided an overview of the action. In the *Status of the Species* and *Environmental Baseline* sections of this Opinion, NMFS provided an overview of the threatened and endangered species and critical habitat that are likely to be adversely affected by the activity under consultation.

Regulations that implement section 7(b)(2) of the ESA require that biological opinions evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). Section 7 of the ESA also requires biological opinions to determine if Federal actions would destroy or adversely modify the conservation value of critical habitat (16 U.S.C. §1536).

NMFS generally approaches "jeopardy" analyses in a series of steps. First, NMFS evaluates the available evidence to identify direct and indirect physical, chemical, and biotic effects of the proposed action on individual members of listed species or aspects of the species' environment (these effects include direct, physical harm or injury to individual members of a species; modifications to something in the species' environment - such as reducing a species' prey base, enhancing populations of predators, altering its spawning substrate, altering its ambient temperature regimes; or adding something novel to a species' environment - such as introducing exotic competitors or a sound). Once NMFS has identified the effects of the action, the available evidence is evaluated to identify a species' probable response (including behavioral responses) to those effects to determine if those effects could reasonably be expected to reduce a species' reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; among others). The available evidence is then used to determine if these reductions, if there are any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild.

The regulatory definition of adverse modification has been invalidated by the courts. Until a new definition is adopted, NMFS will evaluate destruction or adverse modification of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species.

A. Approach to Assessment

1. Information Available for the Assessment

To conduct the assessment, NMFS examined evidence from a variety of sources. Detailed background information on the status of these species and critical habitat has been published in a number of documents including peer reviewed scientific journals, primary reference materials, governmental and non-governmental reports, and scientific meetings as well as the supporting information supplied with the action's environmental documents.

2. Assumptions Underlying This Assessment

In the absence of definitive data or conclusive evidence, NMFS must make a logical series of assumptions to overcome the limits of the available information. These assumptions will be made using sound, scientific reasoning that can be logically derived from the available information. The progression of the reasoning will be stated for each assumption, and supporting evidence cited.

In assessing the effects of fluridone upon listed salmonids, NMFS has utilized data provided by the applicant as well as that which is available in the literature. In instances where information is insufficient to make these assessments, NMFS must make assumptions based on sound logic. These assumptions are derived from the various scientific disciplines associated with the effects of the project and are based on the available scientific literature. In particular, the effects of low doses (or concentrations) of the fluridone compound which do not elicit obvious, visually observable effects must be interpolated from the various disciplines of science, including toxicology, ecology, and physiology. The exposure data provided by the applicant is gross in its generality, and has limited tissue, cellular, or molecular based data to determine the true extent of effects resulting from exposure to the fluridone compound.

No toxicity data pertinent to the proposed project could be found for North American green sturgeon. Therefore, NMFS extrapolated the available toxicity data for other fish species to green sturgeon, and then examined the level of expected exposure to both juveniles and adults by using the known behavioral characteristics of sturgeon to assess risk.

B. Assessment

The USDA-ARS and DBW have requested a one year extension to the currently standing biological opinion for the EDCP which assesses the effects of fluridone treatments on listed salmonids in the Delta region, and which limits the application season from April 1 to October 15 in selected water bodies. Within the Delta, this treatment period overlaps three months

(April, May, and June) of adult winter-run Chinook salmon migration and two months (April and May) of juvenile winter-run Chinook salmon emigration; six months of the spring-run Chinook salmon adult migration (April through September) and three months of juvenile spring-run Chinook salmon emigration (April, May and June); and approximately seven months of adult and juvenile steelhead migration in the Delta (April through October). During out-migration, the winter-run juveniles are at sub-yearling stage (age 0); spring-run juveniles are at sub yearling and yearling stage (age 0-1) and steelhead smolts are post-yearlings (age >1).

Adults and juveniles of the southern DPS of North American green sturgeon are expected to be present within the waters of the Delta year round. While specific information regarding the timing and location of sturgeon within the Delta is limited, it is known that adults tend to migrate upstream through the Delta towards spawning grounds in the upper Sacramento River starting in mid winter, with downstream migration occurring over a prolonged period following spawning in late spring. Juveniles are expected to enter the Delta towards the end of summer and into fall following their downstream migration. Juveniles are then expected to rear for several months to years within the Delta, proper, before moving offshore into marine environments.

The application areas that DBW has prioritized for early treatment with fluridone are Frank's Tract (140 acres), Sandmound Slough (38 acres), Rhode Island (66 acres) and Little Potato Slough-Grindstone (8 acres), in that order. Three of these sites, Frank's Tract, Rhode Island, and Sandmound Slough are situated at or near the confluence of the San Joaquin River and Old River channels in the central Delta. Listed salmonids are known to be present in these waters during the time period that DBW intends to apply the fluridone based herbicides. Listed salmonids from the Sacramento River basin gain access to these waters from Georgiana Slough, Three mile Slough and the lower reaches of the San Joaquin River. Listed Central Valley steelhead may access these waters from either the Sacramento River basin or from the San Joaquin River basin, including all of the east side tributaries that flow into the central Delta.

Adult salmonids are not expected to be adversely impacted by the EDCP, as they utilize deep water habitat which is not slated for EDCP chemical control treatments. However, the shallow water "nursery areas" targeted for chemical treatment in the Delta attract juvenile salmonids as these areas provide the necessary forage base and protective cover for them. Salmon juveniles move from tidal channels during flood tide to feed in near-shore marshes. They scatter along the edges of the marshes at the highest points reached by the tide, then with the receding tide, retreat into channels that dissect marsh areas and retain water at low tide. Larger juveniles and smolts tend to congregate in surface waters of main and secondary slough channels and move into shallow subtidal areas to feed. Although there is some evidence that salmon and steelhead may not occur inside dense infestations of *Egeria densa* (McGowan 1998; Grimaldo *et al.* 2000), juvenile salmonids occurring along the edges of these areas would be vulnerable to impacts from the activities of the EDCP. The exact range of these effects would be hard to determine with any precision as they are dependent upon local conditions and physical environment which change with the application locale. These impacts may include physical disturbance during the herbicide application process and mechanical harvesting, direct exposure to chemical herbicides, various sublethal toxicity effects, and effects upon the aquatic habitat such as reduced DO levels, reduced food supply, and removal of native submerged aquatic vegetation.

Information regarding habitat preference for sturgeon is limited. Observations by fisherman and fisheries biologists indicate that sturgeon tend to congregate in deeper channels and holes for prolonged periods, however sturgeon have been routinely captured on shallow flats during different tidal phases in Suisun and Grizzly Bays (CDFG 1957). This behavior may be indicative of foraging behavior by the sturgeon. Therefore, foraging behavior by juvenile and adult green sturgeons along the shallow edges of channels within the Delta cannot be discounted and would thus increase their exposure to the actions of the EDCP.

1. Toxicity of EDCP Herbicides

In a study on toxicities of fluridone to aquatic invertebrates and fish, the acute median lethal concentrations of fluridone were 4.3 ± 3.7 mg/L (mg/L = ppm) for invertebrates, and 10.4 ± 3.9 mg/L for fish (Hamelink *et al.* 1986). Invertebrates were approximately three times more sensitive than fish on an acute basis but about equally sensitive on a chronic basis. However, Paul *et al.* (1994) found that life stage was a critical factor in determining the sensitivity of fish to fluridone. This research found that the early life stages of fish were more sensitive than older life stages and that there were distinct species related sensitivities to the toxicity of fluridone. Paul *et al.* (1994) found that larval walleye (*Stizostedion vitreum*) were the most sensitive of the four different species of fish tested in their studies (1.8 mg/L, 96 hr LC_{50}). This study found that the No Observed Adverse Effect Concentration (NOAEC) was 780 µg/l (ppb) for the same age walleye. Hamelink *et al.* (1986) found that rainbow trout exposed to fluridone had a 96 hr LC_{50} ranging from 4.2 mg/l to 11.7 mg/L with an average of 7.15 mg/L in the twelve different studies reviewed. Similar toxicity ranges are found in the EPA's ECOTOX database for rainbow trout. Exposure data submitted by the applicant found that the 96 hr LC_{50} concentrations for Delta smelt (*Hypomesus transpacificus*) larvae was 6.1 ppm (3.8-9.6: 95% upper and lower confidence levels [CL]), for splittail (*Pogonicthys macrolepididotus*) juveniles the LC_{50} was 23.8 ppm (20.7 – 27.7 CL) and that for fathead minnows (*Pimephales promelas*) the LC_{50} was 6.2 ppm (5.6 -6.7 CL) (CDFG 2002a, b, c, 2004). Further exposure data sponsored by the chemical manufacturer, the SePro Corporation, found that a 61-day early life stage exposure to Chinook salmon eggs starting at 36 days post fertilization, did not elicit significant differences between exposed eggs and control eggs for percentage hatching, fry survival, or growth. Organogenesis in salmon fry is complete prior to 36 days post fertilization and water hardening of the chorion following fertilization minimizes the diffusion of large molecular weight compounds through the chorion. Histopathological examination of surviving fry did not find any significant abnormalities at the end of the 61-day exposure period for brain tissue. Based on the histopathology done by the applicant's laboratory, the No Observable Effects Concentration (NOEC) and Lowest Observable Effects Level (LOEC) for gill tissues were 0.222 and 0.430 ppm and for liver tissue 0.848 and 1.71 ppm respectively. There was a clear dose dependent trend in both the prevalence and severity of diffuse hypertrophy of the gill epithelium in fish exposed to 0.430, 0.848, and 1.71 ppm fluridone. Epithelial cells were more affected than chloride cells. Decreased hepatocellular vacuolization was clearly seen in Chinook salmon fry exposed to the highest concentration of fluridone (1.71 ppm). Similar, but more subtle changes occurred at the other fluridone concentrations tested but were not statistically significant compared to the control fish. A significant reduction in mean standard length (4.5 percent) was observed at the highest concentration tested (1.71 ppm) compared to the control fish. A subsequent study sponsored by the SePro Corporation comprised an acute toxicity test and a seawater challenge test to assess the effects of the fluridone compound on juvenile Chinook salmon. The acute toxicity test exposed fish to fluridone concentrations of 0 (control), 0.40, 0.80, 1.6, 3.2, and 6.3 ppm active ingredient for 96 hours. The second portion of the exposure test challenged Chinook salmon juveniles to 24 hour direct seawater exposures (30 ± 1 ppt) following 96 hour exposures to nominal fluridone concentrations of 0, 0.030 and 0.210 ppm active ingredient. Mortalities were seen in fish exposed to fluridone concentrations over 0.725 ppm fluridone. Mortalities occurring in the fish exposed to 1.53 and 3.06 ppm fluridone were due to fish jumping out of the tank following exposure to the compound. No fish jumped out of the lower concentration exposure tanks. Gross behavioral and physical signs of sublethal effects were observed in exposure tanks with fluridone concentrations higher than 1.53 ppm. These effects included dark coloration, loss of equilibrium, erratic swimming patterns, quiescent resting on the bottom of the tank for prolonged periods, and surfacing behavior. There were slight differences in the hematocrit of saltwater challenged fish that reflected a dose dependent shift in the hematocrit values. Only the highest fluridone concentration (0.209 ppm) and the control were statistically different. Both the highest dose and the control overlapped with the intermediate concentration in hematocrit levels. All hematocrit values fell within the normal physiological ranges reported for Chinook salmon. The values for serum sodium concentrations did not show any significant trends for the different fluridone exposure concentrations, indicating that sodium levels in the blood did not appear to be affected by fluridone exposure following a salt water challenge. The applicant has also referred to unpublished studies at the University of Washington in which both Chinook salmon and coho salmon (*O. kitsuch*) were exposed to different concentrations of fluridone and then challenged with seawater (27 to 28 ppt). Preliminary results indicate that Chinook salmon exposed to 90 ppb fluridone did not have any statistically significant differences from the control group in measured parameters (*i.e.* smolt survival, body weight, fork length, hepatosomatic index, muscle water content, assays of plasma Na^+ and Cl^- concentrations, assays of gill ATPase activity and gill histology). Likewise, coho salmon exposed to 10 ppb fluridone did not exhibit any statistically different responses to the compound than they did to control conditions. NMFS has not had the opportunity to review these reports first hand, but has requested them from the authors at the University of Washington.

NMFS has queried the EPA AQUIRE database for fluridone toxicity exposure studies concerning sturgeon and did not find any entries. Therefore, NMFS will assume that green sturgeon will be protected by the lowest toxicity levels found in the literature (780 ppb).

CDFG prepared reports (2004d) on the exposure of *Ceriodaphnia dubia,* a freshwater invertebrate, to fluridone. The *C. dubia* were exposed to five concentrations of fluridone in addition to the control water for seven days (7-d) under static chamber conditions. The 7-d LC_{50} value for fluridone was 6.9 mg/L. There was a statistically significant difference in reproductive capacity between the control and daphnia exposed to fluridone concentrations ≥4.6 mg/L. The effects curve indicated that the slope was very steep for the fluridone exposure tests, indicating a very narrow margin of safety fluridone at concentrations that elicit effects. In other studies, no chronic effects were appreciably detected in daphnids (*Daphnia magna*) at 0.2 mg/L concentration, amphipods (*Gammarus pseudolimnoeus*) at 0.6 mg/L, or midge larvae

(*Chironomus plumosus*) at 0.6 mg/L. Channel catfish (*Ictalurus punctatus*) were not adversely affected by an exposure to 0.5 mg/L fluridone; however, their tissue had fluridone concentrations at two to nine times greater than that in the water column. Rainbow trout had an even higher bio-concentration ratio of fluridone in their tissue, ranging from 2.3 times ambient water concentration in the edible tissue to 23.4 in the inedible portions with a whole body average of 15.5 (West *et al.* 1983). An initial fluridone concentration of 0.1 mg/L (ppm) or less is recommended to not adversely affect aquatic life (Hamelink *et al.* 1986).

Reward® (*i.e.*, diquat) is moderately toxic to fish in fresh water with 96-hr LC_{50} values ranging from 10 - 30 mg/L (Lorz *et al.* 1979, Etoxnet 2001). Toxicity of diquat to fish varies with species and life stage, and with water hardness and pH (Lorz *et al.* 1979; Shaw and Hamer 1995). There is also some data that suggest that diquat is more toxic at higher temperatures (Paul *et al.* 1994). Photodegradation plays a small part in the removal of diquat from the water column, but the Delta's hard water affords some protection to fish by the chelation of diquat. Label instructions for diquat specify that application rates in shallow water (<1 m) should be reduced, and diquat use should be discouraged in water bodies containing sensitive fish species during their early life stages (Paul *et al.* 1994). Aquatic organisms are usually exposed to multiple lower-level exposures (Campbell *et al.* 2000). *Hyalella azteca*, an amphipod, is one of the most sensitive aquatic organisms tested, with a 96-hour LC_{50} of 0.048 mg/L (Wilson and Bond 1969). The 8-hr LC_{50} for diquat is 12.3 mg/L in rainbow trout and 28.5 mg/L in Chinook salmon. The 96-hr. LC_{50} for diquat is12 mg/L for rainbow trout and 28.5 mg/L for fingerling trout (Kamrin 1997). The use of diquat at recommended treatment levels could delay downstream migration of smolts and possibly affect their survival in seawater (Lorz *et al.* 1979). The EPA's water quality criteria (1973) has established a criterion of 0.5 mg/L (ppm) diquat (instantaneous maximum) as the concentration that is protective of freshwater aquatic life.

NMFS has queried the EPA AQUIRE database for diquat toxicity exposure studies concerning sturgeon and did not find any entries. Therefore, NMFS will assume that green sturgeon will be protected by the lowest toxicity levels found in the literature.

Juvenile salmonids could be exposed to elevated concentrations of fluridone or diquat from the EDCP if they are present near the herbicide application point during the treatment process. Concentrations would remain high until the chemical is diluted from mixing with Delta waters. Rough estimates for herbicide concentration immediately following the initial application range from ten to twenty times the target concentration in the first six inches of water around the point of application. Lethal concentration of diquat may be reached temporarily in waters immediately adjacent to the injection point and prior to any mixing, but the duration of these concentrations are anticipated to be very short. Pelleted fluridone (Sonar PR), due to its slow release characteristics, is not anticipated to reach the very high concentrations in close proximity to the compound application point as seen with the aqueous formulations of the two herbicides. Mixing is expected to occur fairly rapidly (*i.e.*, minutes to hours) in most application sites utilizing an aqueous herbicide formulation. Dissipation studies conducted by the applicant (USDA-ARS 2004) indicate that following an aqueous herbicide application (Sonar AS), the highest concentrations are reached in the surface layers of the water column within the first 1 to 2 hours. Maximal surface concentrations of fluridone reached 50 to 75 ppb in these first few hours (averaging 20 to 50 ppb), and then gradually declined over time. Fluridone concentrations from the bottom of the water column indicated that concentrations gradually rose over time, indicating water column mixing from the surface application. Full water column mixing was generally achieved by 24 hours and leveled off at approximately 20 percent of the maximal surface concentration (approximately 10 to 15 ppb). It was apparent from the data submitted that dilution and mixing of the fluridone application was strongly influenced by channel geometry and water flow through the channel. In one of the channels monitored, a bimodal peak in surface concentration of the fluridone was observed following the change of the tidal flow past the monitoring station.

Once the fluridone application occurs, then assuming the worst case scenario, and using the highest predicted environmental concentration (*i.e.*, 75 ppb) and the LC_{50} for rainbow trout (*i.e.*, 4.2 ppm), the instantaneous concentration for fluridone in the treatment area is expected to be approximately 56 times lower than the 96 hour LC_{50} for fluridone for approximately two hours. Taking the 24-hour averaged water column concentration of 12 ppb, the ratio between the LC_{50} and the averaged water column concentration is approximately 380. Likewise for diquat when complete mixing occurs, then assuming the worst case scenario, and using the highest predicted environmental concentration (*i.e.*, 0.37 ppm) and the most sensitive LC_{50} (*i.e.*, 0.74 ppm), the instantaneous diquat concentration is still two times lower than the most sensitive LC_{50} values which are for larval fish. The instantaneous concentration for diquat, following complete mixing, is almost 77 times lower than the published LC_{50} values for Chinook salmon and 31 times lower than those for rainbow trout. NMFS could not find published toxicity values for sturgeon species exposed to fluridone or diquat.

Both fluridone and diquat are expected to be adsorbed to particulate matter suspended in the water and onto sediments on the bottom of the Delta waterways. Bacterial degradation will remove fluridone from the system and metabolize it to simple carbon compounds. Fluridone will also undergo photolytic decomposition. The half-life for fluridone in aquatic environments is approximately 21 days (Extoxnet 2002), but it may remain in bottom sediments from several weeks to one year (Muir and Grift 1982). Diquat chemically binds to sediment quickly (Ritter *et al.* 2000). Paul *et al.* (1994) found that sediment removed 60 percent of the diquat after four days in a shallow container which continued to be mixed by aeration. Several other field studies with variable results indicate the difficulty in ascertaining the time and rate of diquat dissipation (Yeo 1967), but apparently it can remain bioavailable for several days (Paul *et al.*1994). The environmental fate characteristics of both Sonar® and Reward® and the application rates used in the EDCP indicate that the long-term concentration levels of the herbicides achieved in Delta waters should be significantly below the acute toxicity levels of listed salmonids. However, recent medical studies in humans have shown correlations with the usage of herbicides, particularly phenoxy acetic acid herbicides (*e.g.*, 2,4- D) to increases in spontaneous abortions (Arbuckle, Lin and Mery 2001) in Ontario farm populations, presence of phenoxy residues in Ontario farmers' sperm (Arbuckle *et al.* 1999), parkinsonism from glyphosate exposure (Barbosa *et al.* 2001), short term decreases in immunological indices in farmers exposed to phenoxy herbicides (Faustini *et al.* 1996), and an increased risk of non-Hodgkin lymphoma from herbicide and pesticide exposures (Lynge 1998, Hardell and Eriksson 1999, McDuffie *et al.* 2001). The epidemiological data for humans exposed to herbicides would indicate that there is sufficient concern to warrant restricted usage of the compounds in aquatic environmental settings until more extensive physiological research is conducted.

In any case, sublethal effects and effects on habitat resulting from the EDCP that may ultimately increase the likelihood of mortality of salmon and steelhead are of concern, and are the category of effects that are most likely to occur during this program. Sublethal effects are characterized as those that occur at concentrations that are below those that lead directly to death. Sublethal effects may impact the fish's behavior, biochemical and/or physiological functions, and create histological alterations of the fish's anatomy. In addition, changes in the sensitivities of fish to other contaminants (*i.e.*, chemical synergism), particularly pesticides and other aromatic hydrocarbons, may increase the mortality of exposed fish. Degradation of habitat is expected to occur due to decreases in DO level due to *Egeria* decomposition, decreases in native vegetative cover, decreases in the invertebrate standing population which reduces the forage base available to juvenile salmonids, and changes in ambient water temperature due to changes in the amount of vegetative cover.

2. Sublethal Effects

In contrast to the acute lethality endpoints associated with the EDCP, nonlethal or sublethal endpoints may be more appropriate to the levels of exposure likely to be seen in the herbicide application protocol employed in the EDCP. Sublethal or nonlethal endpoints do not require that mortality be absent; rather, they indicate that death is not the primary toxic endpoint being examined. Rand (1995) states that the most common sublethal endpoints in aquatic organisms are behavioral (*e.g.*, swimming, feeding, attraction-avoidance, and predator-prey interactions), physiological (*e.g.*, growth, reproduction, and development), biochemical (*e.g.*, blood enzyme and ion levels), and histological changes (*e.g.*, degenerative necrosis of the liver, kidneys, and gill lamellae; Lorz *et al.* 1979). Some sublethal effects may indirectly result in mortality. Changes in certain behaviors, such as swimming or olfactory responses, may diminish the ability of the salmonids to find food or escape from predators and may ultimately result in death. Some sublethal effects may have little or no long-term consequences to the fish because they are rapidly reversible or diminish and cease with time. Individual fish may exhibit different responses to the same concentration of toxicant. The individual condition of the fish can significantly influence the outcome of the toxicant exposure. Fish with greater energy stores will be better able to survive a temporary decline in foraging ability, or have sufficient metabolic stores to swim to areas with better environmental conditions. Fish that are already stressed are more susceptible to the deleterious effects of contaminants, and may succumb to toxicant levels that are considered sublethal to a healthy fish.

a. *Narcosis*

Fish, when exposed to elevated concentrations of polar and nonpolar organic compounds such as the herbicides used in the EDCP, can become narcotized. Narcosis is a generalized nonselective toxicity response that is the result of a general disruption of cell membrane function. The process of narcosis is poorly understood, but is thought to involve either a "critical volume" change in cellular membranes due to the toxicant dissolving into the lipid membrane and altering its function, or by the "protein binding" process in which hydrophobic portions of receptor proteins in the lipid membrane are bound by the toxicant molecules, thus changing the receptor protein's function (Rand 1995). Exposure to elevated concentrations of the herbicides would occur in the immediate area of herbicide application, prior to dilution in the surrounding water column. A fish with narcosis would be more susceptible to predation as a result of a loss of equilibrium, a reduction in swimming ability or a lack of predator avoidance behavior. Furthermore, a fish with narcosis would also have difficulty maintaining its position in the water column, and could potentially be carried by water currents into areas of sub-optimal water quality where conditions may be lethal to salmonids (*e.g.*, hypoxic regions within *Egeria* mats). Behavior seen in the applicant's studies for the acute response of Chinook salmon smolts to increasing concentrations of fluridone indicate that grossly observable responses to the compound occurred at concentrations $\geq$ 1.53 ppm. Reductions in the behavioral response time or response level tostimuli (*e.g.* food or predators) frequently occur at concentrations lower than those that elicit grossly observable responses.

b. *Rheotropism*

Rheotropism refers to fish behavior in a current of water, either directly as a response to water flowing over the body surface or indirectly as a response to the visual, tactile or inertial stimuli resulting from the displacement of fish in space (Dodson and Mayfield 1979). Fish respond physically and behaviorally to foreign stimuli (see Appendix C). Rainbow trout yearlings exposed to 0.5 ppm and 1.5 ppm of diquat for 24 hours exhibited no significant variation in the frequency of positive rheotaxis, exhibiting an increase in the frequency of no response and a significant decrease in swimming speeds caused by short-term exposure to diquat (Dodson and Mayfield 1979). Subtoxic effects of diquat on yellow perch (*Perca flavescens*) include a level of respiratory stress indicated by the cough response and reduced swimming speeds in exposure to 1.0 to 5.0 ppm diquat over 48 hours to 72 hours (Bimber *et al.* 1976). Fish exposed to diquat over longer periods of time may move passively downstream and into decreasing concentrations of diquat, exhibiting a passive avoidance response. The level of chemical absorption is dependent upon the fish species as well as individual fish characteristics. Hiltebran *et al.* (1972) exposed bluegills (*Lepomis macrochirus*) to diquat and demonstrated that as the length of exposure time increased, proportionally less diquat appeared to have been absorbed. It was unknown if this result was due to the metabolism, or elimination, of diquat. A "leveling off" of diquat residues in fish tissue was observed in increasing diquat concentrations rather than with increasing exposure time (Dodson and Mayfield 1979). No information was found concerning fluridone's effects on rheotropism.

c. *Chemical Interactions*

Rand (1995) states that in "assessing chemically induced effects (responses), it is important to consider that in the natural aquatic environment organisms may be exposed not to a single chemical but rather to a myriad or mixture of different substances at the same or nearly the same time. Exposures to mixtures may result in toxicological interactions." A toxicological interaction is one in which exposure to two or more chemical residues results in a biological response quantitatively or qualitatively different from that expected from the action of each chemical alone. Exposure to two or more chemicals simultaneously may produce a response that is simply additive of the individual responses or one that is greater (synergistic) or less (antagonistic) than expected from the addition of their individual responses. Application of herbicides from the EDCP project may contribute to elevated toxicological responses caused by unknown sources of chemical compounds within the project area. Over 30 different herbicides are applied annually on agricultural lands in the Delta, and an additional 5 million pounds are applied upstream in the Sacramento River, San Joaquin River, and French Camp Slough (Kuivila *et al.* 1999). Chemicals used by the EDCP may build up on sediments at treatment sites. High additive concentrations of the various herbicides utilized in the Central Valley can potentially impair primary production in a defined geographic area (Kuivila *et al.* 1999) if contaminated waters come together in a confined area. Waters that flow through treated locations can carry herbicides to adjacent areas while concentrations in the water are still high enough to cause adverse impacts to aquatic organisms, if present, and possibly irrigation, municipal waste supplies and recreation.

Exposure of fish to the aromatic hydrocarbons typical of many families of herbicides and pesticides may result in the biotransformation of these compounds by various enzyme systems in the fish. Most organic contaminants are lipophilic, a property that makes these compounds readily absorbed across the lipid membranes of the gill, skin, and gastrointestinal tract. Following absorption, compounds that are susceptible to biotransformation are converted to more water soluble metabolites that are easier to excrete than the parent compound. Compounds that are resistant to metabolism are often sequestered in the lipid-rich tissues of the body. Although biotransformation is often considered a positive event in the detoxification of the contaminant, the parent compound of some contaminants are actually less toxic than the metabolites formed. These reactive intermediate metabolites can cause significant problems in other metabolic pathways, including alterations in the synthesis of DNA and RNA, redox cycling of reactive compounds, and induction of enzymatic systems that could lead to altered metabolism of environmentally encountered contaminants (Di Giulo *et al.* 1995). Within the Delta, mixtures of contaminants, particularly organophosphate pesticides (OP's) are common. Induction of the biotransforming enzymatic pathways, particularly the p450 monooxygenases, may actually increase the sensitivity of a fish to environmental contaminants. Organophosphate insecticides often are activated by the monooxygenase system (Murty 1986; Dr. M.J. Lydy, Southern Illinois University, Carbondale, personal communication, 2003), thus the higher the activity of the monooxygenase system, the more reactive metabolite formed.

d. *Immunotoxicity*

The fluridone compound is a three ringed aromatic compound with a trifluromethyl substitution on one phenyl ring, a methyl substitution on the pyridinone ring, and the third ring being an unsubstituted phenyl ring. Exposure to polycyclic aromatic hydrocarbons (PAHs) and other aromatic compounds typical of hydrocarbon contamination from industry, chemical spills, and engine exhausts was shown to suppress immune responses in fall-run Chinook salmon (*O. tshawytscha*) in the Pacific Northwest by Varanasi *et al.* (1993) and Arkoosh *et al.* (1998, 2001). This research indicated a high correlation between exposure to sediments, which contained elevated levels of aromatic and chlorinated organic compounds indicative of contaminants found in urban estuaries, and reductions in the primary and secondary humoral immune responses of juvenile Chinook salmon. The 1998 study indicated that this response resulted from both direct exposure and through the benthic species in the forage base of the fish sampled from the estuaries. Significant concentrations of these organic contaminants were bioaccumulated by the juvenile Chinook salmon during their relatively short residence time in the estuary. The followup study in 2001 exposed the marine-adapted smolts of Chinook salmon to the aromatic and chlorinated organic compounds extracted from contaminated sediments through intraperitoneal injections and then measured their response to the marine bacterial pathogen, *Vibrio anguillarum*. The exposed fish suffered significantly higher pathogen-related mortality than the control fish. These results further indicated that although the exposure of juvenile fish migrating through the estuary is relatively short in duration, the immunosuppression may extend into their early ocean life, thus potentially influencing recruitment to adult stages later on. Recent studies presented at the American Fisheries Society (AFS) California-Nevada Chapter meetings in Sacramento, California, indicate that exposure to certain pesticides, *i.e.* the synthetic pyrethroid esfenvalerate, enhanced the infectious activity of the pathogen responsible for infectious hematopoietic necrosis virus (IHNV) in juvenile Central Valley fall-run Chinook salmon (*O. tshawytscha*). Viral assays of the dead fish indicated a lethal synergism of esfenvalerate and IHNV at levels of the pesticide considered non-lethal to the exposed Chinook salmon (Clifford *et al.* 2005). Other studies presented as posters at this meeting indicated that exposure to different pesticides (*i.e.* chlorpyrifos and esfenvalerate) induced heatshock proteins and cytokines, both indicators of environmental stress at sublethal concentrations in fall-run Chinook salmon (Eder *et al.* 2005a, b).

e. *Summary*

In summation, all fish exposed to the chemical constituents in the herbicides will be expected to exhibit some level of adverse effects. Acute direct exposures to higher concentrations of the active ingredients can result in death. On the other hand, exposures to lower concentrations of the active ingredients in the herbicides will result in a spectrum of responses ranging from avoidance reactions and mild physiological disturbances to long term morbidity and shortened life span. Exposure of listed fish to these herbicides can significantly increase their vulnerability to predation from both piscine and avian predators. Symptoms of behavioral and physiological perturbations resulting from exposure often make affected fish stand out to predators from their unexposed cohorts. Longer term impacts will include a decrease in the physiological health of exposed fish after they leave the application area, as described in the immunotoxicity subsection above. These adverse effects are expected to be magnified by the conditions present in the Delta during the project's application schedule. The degraded habitat that is currently representative of the Delta exposes listed salmonids to a myriad of chemical constituents, many of which are known to have toxic effects on salmonids. The multiple exposures of the fish to different compounds in the water, in addition to the exposure of the fish to the active compounds in the EDCP's proposed herbicides, is likely to exacerbate the rate of morbidity and mortality in exposed fish. The indications of these adverse effects may not present themselves for days to months following the exposure, and may be very subtle in nature, but will produce fish with a lowered chance of survival and hence a lowered chance for contributing to the recovery of the fish's population.

3. Effects on Habitat

a. *Physical Disturbance*

Operation of the program's watercraft in the project area may result in effects due to wake turbulence, sediment resuspension, physical impact with propellers, and discharge of pollutants from the motor's exhaust and lubrication systems. These impacts may be exacerbated because the *Egeria*-infested areas tend to be shallow and the dense vegetation mats retain suspended particulates on their leaves. Wake induced turbulence in these areas disturbs the sediments captured by these plants and resuspends it all at once into the adjacent water column. The interaction of propellers with the vegetation shreds the plants into smaller fragments, some of which may retain their propagative viability if two internodes remain on the fragment.

Mechanical harvesting removes plants from the water by cutting them above their attachment point to the hydrosoil (mechanical cutting). Mechanical cutting is limited to relatively shallow waters, less than 10 feet deep. Cutter bars slice through the submerged stems of the plants and a conveyor belt-like mechanism moves the harvested plant material to a receiving craft or barge. When full, the barge moves to a shore mounted conveyor belt where it is transferred to a disposal vehicle. Mechanical harvesting has the potential to create significant amounts of viable fragments, which could then re-establish themselves elsewhere. In addition, the cutter bar assembly and harvesting apparatus may startle and drive listed salmonids out of the work area during its operation. However, the presence of juvenile salmonids in heavily infested areas where emergency mechanical harvesting may occur is unlikely due to their habitat preferences.

b. *Dissolved Oxygen Levels*

Juvenile salmonids may be directly affected through the reduction in DO levels resulting from the decomposition of plants killed by the herbicide application. Low DO levels (< 3 mg/L) can result in fish kills if fish are unable to move out of the zone of hypoxic or anoxic waters. Low dissolved oxygen levels are particularly harmful to salmonids, which have a high metabolic requirement for dissolved oxygen (Bjornn and Reiser 1991). Studies have shown that dissolved oxygen levels below 5 mg/L have a significant negative effect on salmonid growth, food conversion efficiency, and swimming performance. High water temperatures, which result in reduced oxygen solubility, can compound the stress on fish caused by marginal DO concentrations (Bjornn and Reiser 1991). Stress from low DO can make juvenile salmonids more susceptible to predation and disease, and less likely to smolt due to insufficient energy reserves. Adult salmonids may experience delayed migration through Delta waters if DO is below concentrations needed for survival. Delay in upstream migration can have a negative impact on the maturation of gonadal tissue, particularly if ambient water temperatures in the Delta are also elevated. Salmonids exposed to elevated temperatures during gonadal maturation have reduced fertility and lower numbers of viable eggs (CALFED 2000a). Fish exposed to DO levels below 5 mg/L for extended periods are usually compromised in their growth and survival (Piper *et al.* 1982). NMFS expects that fish and mobile invertebrates will generally avoid areas with extensive infestations of *Egeria* due to the decreased ambient levels of DO in the water column. The increased biomass of the floating *Egeria* mat will increase the respiratory burden on DO during the night and limit light penetration to submerged portions of the plants during the day. Increased detrital deposition below the *Egeria* due to reduced water flow, and plant matter falling from the overlying mats will increase biological oxygen demand (BOD) in the affected areas of the infestation. The applications of herbicides are expected to initially decrease DO levels even further in areas treated for the plant. This results from the decomposition of the dead vegetable matter and an increase in BOD. This effect is expected to be transitory as the decaying vegetation is dispersed by tidal and river currents from the treatment area. Areas of higher tidal and river current exposure will be flushed faster than areas of low water body exchange, such as dead end sloughs and restricted peripheral channels. Additional parameters affecting the DO levels are the rate of decay for the treated vegetation which is dependent on ambient water temperature and microbial activity. Higher water temperatures should theoretically result in higher microbial activity, thus resulting in a faster decline in the DO levels. However, the duration of the depressed DO levels should be shorter than in a cooler temperature profile due to the vegetative biomass being metabolized at a faster rate. Conversely, a cooler ambient temperature would result in a prolonged DO depression, although perhaps not to the hypoxic levels reached in a warmer water profile.

c. *Invertebrate Populations*

Invertebrates could be exposed to elevated concentrations of fluridone or diquat from the EDCP if they occur within the immediate area of the initial application of the herbicidal concentrate to the water column. After mixing, however, the chemical compounds should not reach toxic levels to invertebrates if they are applied at the labeled rates. The volume of water available for dilution of the applied herbicide and the rate of water exchange will determine the extent of the elevated herbicide residues in the water column. The annual monitoring reports have indicated occasional elevated toxicity to *daphnia* spp. from monitored sites following herbicide applications, although direct correlations to the herbicide concentration has not been definitively made. Regions of low dissolved oxygen caused by drifting mats of decaying vegetation or smothering of benthic substrate may cause a localized decrease in populations and diversity of invertebrates. Many invertebrates have limited ability to migrate out of the treatment area, and thus are more susceptible to the effects of elevated herbicide concentrations or low dissolved oxygen levels. Following treatment, new populations of invertebrates are expected to re-establish themselves through larval recolonization of the area as soon as habitat conditions are suitable for their growth. Although the project's supporting material describes this mechanism, the project does not have actual data from the program to support this position. Nevertheless, juvenile salmonids will at least temporarily have to enlarge their foraging area to obtain sufficient prey to support their caloric needs. This may increase their exposure to predators, thereby decreasing their probability of survival. Also, the rate of survival for juvenile salmonids would be a balance between the amounts of metabolic energy expended in swimming during foraging behavior versus the amount of caloric intake achieved from the prey captured during foraging. Caloric intake needs to exceed the metabolic cost of swimming in order for the juvenile fish to have sufficient energy reserves for growth and other metabolic needs.

d. *Native Vegetation*

There are potential impacts to native submerged and emergent vegetation especially if Sonar® (*i.e.*, fluridone) treatment is done adjacent to such areas and water column concentrations are sustained at treatment levels for approximately six weeks. Long-term exposure could significantly alter existing local plant community composition adjacent to these treatment sites due to the rates of recolonization and species abundance for pioneering plants. When applied at label rates, fluridone is toxic to other aquatic plants and agricultural crops it comes in contact with for an extended period of time.

Native submerged and emergent vegetation may be harmed or killed by the application of herbicides during the EDCP depending on the level of exposure. However, as with losses of invertebrates, NMFS believes that a reduction in native vegetation would be temporary, as adjacent plants should recolonize the treated area. Removal of the thick mats of *Egeria* will allow light penetration to submerged plants in areas previously shaded by these mats. Likewise, *Egeria* will not be able to smother and abrade native emergent plants. Treated areas will also allow the native plants the opportunity to re-colonize without competing with *Egeria* for space and nutrient resources. During periods of juvenile salmonid migration, treated areas may not provide the necessary vegetative cover or food resources needed by the fish. Treatment could possibly magnify this impact, increasing the areas devoid of aquatic vegetation or having compromised water quality. NMFS believes that these localized effects will reduce the probability of survival of juveniles emigrating through or rearing in the treatment area. Adjacent untreated acreage could be available to provide shelter and foraging for the juvenile salmonids as they move out of the treated area. However, expenditures of valuable metabolic reserves will have to be utilized for swimming to these new areas, making these reserves unavailable for other physiological needs like growth or smoltification. This shift in the utilization of metabolic energy stores has the potential to decrease the survival probability and physical health of the juvenile salmonid.

e. *Beneficial Effects*

Reductions in the percentage of *Egeria densa* infested waterways are likely to increase the habitat area available for use salmonids. It may also result in increased flows through these waterways, increased sunlight penetration, and re-establishment of native aquatic vegetation, and recolonization of native invertebrate species. These changes may result in positive effects on the suitability of the Delta waterways for salmonid rearing and migration.

VI. CUMULATIVE EFFECTS

For purposes of the ESA, cumulative effects are defined as the effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultations pursuant to section 7 of the ESA.

Non-federal actions that may affect the action area include ongoing agricultural activities and increased urbanization. Agricultural practices in the Delta may adversely affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the Delta. Unscreened agricultural diversions throughout the Delta entrain fish including juvenile salmonids. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the Delta. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may adversely affect salmonid reproductive success and survival rates (Dubrovsky *et al.* 1998, 2000; Daughton 2003).

The Delta and East Bay regions, which include portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus and Yolo counties, are expected to increase in population by nearly 3 million people by the year 2020 (California Commercial, Industrial and Residential Real Estate Services Directory 2002). Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Portions of the project site are within the region controlled by San Joaquin County Council of Governments. The General Plans for the City of Stockton and surrounding communities anticipate rapid growth for several decades to come. The anticipated growth will occur along both the I-5 and US-99 transit corridors. Likewise, increased growth is expected along the I-5 and highway 205 corridors in southern San Joaquin County near the cities of Lathrop and Tracy. Anticipated growth in the foothills along the eastern edge of the Central Valley will place greater strains on current water supplies. Current instream flows may be compromised if water demands switch from agricultural based needs to municipal and industrial needs, which have less flexibility in their curtailment during droughts.

Increased urbanization also is expected to result in increased wave action and propeller wash in Delta waterways due to increased recreational boating activity. This potentially will degrade riparian and wetland habitat by eroding channel banks and mid-channel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation. This in turn would reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids. Increased recreational boat operation in the Delta will likely also result in more contamination from the operation of engines on powered craft entering the water bodies of the Delta.

VII. INTEGRATION AND SYNTHESIS

The degree to which listed salmonids may be impacted by the EDCP is a function of their presence within the action area. The proposed period of implementation of the EDCP is from March 1 through November 30, which would overlap with more than half of the adult and juvenile migration periods for all of the runs. The period of greatest overlap with the listed juvenile salmonids in the Delta is during the higher flow periods of spring (*e.g.*, from March 1 through June 1) and fall (*e.g.*, October 1 through November 30). The implementation of the terms and condition from the August 11, 2003 biological opinion has reduced this period of exposure. The remainder of the proposed application season corresponds to a period when there is a low density of listed salmonids in the action area. Both adult and juvenile green sturgeon are expected to spend considerably more time in the waters of the Delta and are believed to be present year round. Therefore, sturgeon will be expected to be present in the waters of the Delta during the application season of the EDCP.

Based on the foregoing analysis, NMFS anticipates that applications of Sonar® or Reward® to the waters of the Delta and its tributaries during the EDCP treatment seasons in an effort to control *Egeria densa* will not result in acute lethal effects to listed salmonids, unless fish are present in the immediate area during or immediately after the herbicide is applied and before dilution can occur through mixing. Nonetheless, there is the potential for the loss of a certain fraction of the migrating population that is exposed to the toxicants. Although fish should not be present in the cores of *Egeria* mats, they may be present along the periphery of the mats, utilizing it for cover from overhead predators. Thus, fish may be exposed to lethal or sublethal concentrations of herbicides that are applied to the margins of the mat or to herbicides present in the water column directly below the mat or flowing out of the area of application. Similarly, adult and juvenile green sturgeon may be present along the periphery of *Egeria* beds as they move up onto shallow water flats to feed. Treatment of *Egeria* beds while sturgeon are present on the flats may expose some individuals to high concentrations of the herbicides, but the length of exposure is anticipated to be of a relatively short duration due to mixing and tidal flow with the surrounding water masses.

The most important impacts of the EDCP are expected to occur to juvenile salmonids and green sturgeon, and include sublethal effects and effects to habitat. As stated in Rand (1995), sublethal effects can be expected to take the form of behavioral, physiological, biochemical, or histological changes in the exposed fish. These changes may not be immediately lethal, but can cause fish to exhibit impaired behaviors (*e.g.*, narcosis) or eventually develop a lesser level of physical health, thus reducing their chances of survival as compared to unexposed fish. Possible consequences include loss of equilibrium and reduced swimming ability and predator avoidance behavior, which could lead to increased predation risk or reduced foraging ability. Chemical synergism between the EDCP herbicides and other contaminants in the Delta could occur and exacerbate these effects.

The EDCP is expected to result in several temporary degraded habitat conditions. These are expected to include physical disturbance, elevation of water temperature caused by reduced shading, reduction of dissolved oxygen levels resulting from decaying *Egeria densa*, reduction in the invertebrate forage base for juvenile salmonids and green sturgeon, and reduction of native vegetation which juvenile salmonids may utilize for cover. Even though juvenile salmonids and green sturgeon should be able to leave or avoid areas of degraded habitat, they may need to expend valuable metabolic energy to do so. This could result in depleted energy stores that could have been used for other physiological needs, such as growth or smoltification. However, the application of the herbicides will be to discrete sections of the Delta, at specific time points in the application season. Thus the Delta will not be globally impacted at a specific point in time, exposing all listed salmonids and green sturgeon in the Delta at that moment to potentially toxic or adverse concentrations of herbicides; neither will any one segment of the Delta be treated continuously for the entire application season, inhibiting movement through it by listed salmonids or green sturgeon. Also, the intermittent nature of the herbicide applications within a given area of the Delta will allow for a significant dilution effect from water column mixing and chemical degradation to initiate within hours. There will be negative impacts to a proportion of the listed salmonid or green sturgeon populations that are within the immediate vicinity of an herbicidal application at the moment of application or immediately following it. The proportion of fish affected by the application is difficult to determine since it is based on the density of migrating fish and the timing of migration. However, only a small segment of each listed salmonid ESU is expected to be actually exposed to concentrations sufficiently elevated to have a negative impact to the individual fish, and therefore the level of impact to the entire run will not be of a magnitude to appreciably reduce the likelihood of continued existence of that run. Similarly, it is not anticipated that individual green sturgeon will congregate in application areas in high enough numbers to represent a significant proportion of the population, but rather will be dispersed throughout the channels of the Delta.

Critical habitat for Sacramento River winter-run Chinook salmon in the project area is not expected to be adversely modified. The majority of the critical habitat in the project area for this ESU is in the Sacramento River, Steamboat, Cache, and Sutter Sloughs. EDCP operations will be primarily to the south of these waterways in the central and south Delta regions. Critical habitat for the Central Valley spring-run Chinook salmon ESU includes waterways in the central Delta (North Fork Mokelumne River and Georgiana Slough) as well as the main stem of the San Joaquin River below its confluence with the Mokelumne River. The critical habitat for the Central Valley steelhead DPS includes all waters of the Delta that are accessible to anadromous fish, and habitat below the high water line (*i.e.* tidal flats, commonly inundated riparian zones, *etc.*). Critical habitat for spring-run Chinook salmon and Central Valley steelhead is not expected to be permanently affected in an adverse manner, but rather on a temporary basis following herbicide treatment. The degraded habitat conditions eventually will be attenuated as DO levels increase and invertebrates recolonize treated areas. The removal of *Egeria* eventually may improve habitat conditions for juvenile salmonids if water flow improves and native vegetation colonizes the treated areas, creating shaded habitat and diverse foraging opportunities for juvenile salmon. Therefore, the EDCP is not expected to appreciably reduce the conservation value of designated critical habitat for Central Valley spring-run Chinook salmon or Central Valley steelhead. No critical habitat has been designated or proposed for North American green sturgeon at this time.

VIII. CONCLUSION

After reviewing the best available scientific and commercial information, the current status of the Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead, the environmental baseline, the effects of the proposed *Egeria densa* Control Program extension for the 2006 application season, and the cumulative effects, it is

NMFS' biological opinion that the EDCP, as proposed, is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, or the southern DPS of North American green sturgeon, or result in the destruction or adverse modification of the designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, or Central Valley steelhead..

Notwithstanding this conclusion, NMFS anticipates that some activities associated with this project may result in the incidental take of these species. Therefore, an incidental take statement is included with this biological opinion for these actions.

IX. INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NOAA's National Marine Fisheries Service (NMFS) as an act which kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not the purpose of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

Pursuant to section 7(b)(4) of the ESA, the following reasonable and prudent measures are necessary and appropriate to minimize take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon. Because these measures are necessary to protect listed salmonids, they are non-discretionary and must be undertaken by the U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS) so that they become binding conditions of any grant or permit issued to the California Department of Boating and Waterways (DBW) or their agents, as appropriate, for the exemption in section 7(o)(2) to apply. The USDA-ARS has a continuing duty to regulate the activity covered in this incidental take statement. If the USDA-ARS: (1) fails to assume and implement the terms and conditions of the incidental take statement; and/or (2) fails to require the DBW or its agents to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the USDA-ARS and the DBW must report the progress of the action and its impact on the species to NMFS as specified in this incidental take statement (50 CFR §402.14 (i)(3)).

This incidental take statement is applicable to the operations of the *Egeria densa* Control Program (EDCP) as described in the Draft Environmental Impact Report (March 2000; DBW

2000a), EDCP Monitoring Plan (November 2002; DBW 2002) and the EDCP: Addendum to 2001 Environmental Impact Report (DBW 2003). All applications of permitted herbicides as described in the project description for the program will have incidental take coverage as stipulated under the terms of section 7(b)(4) and section 7(o)(2) of the ESA during the operational season approved by NMFS for the period of the one year extension (2006) to the period stipulated in the original biological opinion (BO) which covered the application seasons 2003 through 2005, providing that the terms and conditions of this biological opinion are implemented. The incidental take coverage for this biological opinion will terminate following the close of the 2006 application season. After this time, incidental take of listed species by the EDCP will not be exempt from the take prohibitions of section 9 of the Endangered Species Act (ESA) under the authority of this biological opinion.

A. Amount or Extent of Take

NMFS anticipates that the one-year extension of the EDCP will result in the incidental take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead due to direct and indirect impacts caused by the application of chemical herbicides to waters of the Delta. Any incidental take resulting from the project will most likely be limited to emigrating fry and juveniles present in the Delta action area during the operational season of the EDCP (applicant's proposed implementation period from March 1 through November 30). The incidental take is expected to be in the form of death, injury, harassment, and harm.

The numbers of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead directly taken will be difficult to quantify because dead and injured individuals will be difficult to detect and recover. The greatest level of take for listed salmonids resulting from the implementation of the EDCP is expected to occur during the months of March, April, May, and June when listed salmonids will be present in the Delta waterways. Take is expected to include:

1. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead juveniles and adults harmed or killed from exposure to lethal or sublethal concentrations of fluridone or diquat applied to waters of the Delta during the 1-year extension (2006) of the implementation of the EDCP (applicant's proposed implementation period from March 1 through November 30). NMFS considers that it is unlikely that adult salmonids will be present in the areas where the herbicides are applied to the waters of the Delta. Therefore, NMFS anticipates that incidental take of adult fish is not expected to exceed one individual from each ESU/DPS. The numbers of juvenile winter-run and spring-run Chinook salmon and Central Valley steelhead that utilize Delta waterways within the EDCP action area are hard to estimate due to the high levels of uncertainty surrounding the division of migrating fish between the Sacramento River channel and the channels connecting the Sacramento River with the San Joaquin River through the Central Delta. For the past 6 years, estimates of the population of winter-run sized Chinook salmon entering the Central and South Delta have averaged 46,200 fish for the 4-month period between March and June. Based on the 6-year record,

44,000 winter-run Chinook salmon entered the Central and South Delta during March with an additional 2,000 of these fish migrating through the Central and South Delta in the month of April; hence most incidental take would be expected to occur in March and April. These numbers are products of the estimated take numbers from the CVP and SWP and a theoretical cross-Delta mortality value of 85 percent (higher range estimate) based on the work of Brandes and McLain (2001) and Vogel (2004). Therefore, 46,200 winter-run Chinook salmon are expected to be exposed to the adverse conditions created by herbicide applications under the applicant's proposed EDCP herbicide treatment season (March through November), of which 1 percent will suffer morbidity or mortality (462 fish). This value corresponds to the proportion of the exposed population expected to be susceptible to the adverse effects of the herbicide compounds (an equivalent reduction of two orders of magnitude). If the month of March is restricted from herbicide applications, the exposed population of winter-run Chinook salmon is reduced by approximately 95.4 percent to 2,200 fish. During the same 6-year period, approximately 205,713 spring-run sized Chinook salmon moved through the action area during the March through June period. Using the same rationale, 1 percent of the spring-run Chinook salmon exposed to the adverse conditions of the EDCP herbicide applications will suffer morbidity or mortality (2,057 fish). If herbicide applications in March are eliminated, there is a 23.3 percent reduction in the number of spring-run sized Chinook salmon exposed to the herbicide treatments. NMFS anticipates that 1,580 fish will be taken under this alternative. Central Valley steelhead may move through the Delta during all months of the EDCP applications, but salvage data from the CVP and SWP indicate that approximately 29,800 steelhead will move through the Delta in the 4-month period between March and June, with the majority of fish migrating in March. An additional 125 steelhead are expected to move through the Delta in the fall months of September through November based on the data from the CVP and SWP salvage records. NMFS expects that 300 Central Valley steelhead smolts will experience either morbidity or mortality from herbicide exposure. If herbicide applications are restricted in the month of March, there is an approximately 82 percent reduction in the number of Central Valley steelhead exposed to the herbicides, with an expected take of 55 steelhead from the EDCP herbicide treatments.

2. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead juveniles and adults harmed, harassed, or killed from altered habitat conditions caused by the application of fluridone or diquat to the waters of the Delta during implementation of the EDCP (applicant's proposed implementation period from March 1 through November 30) during the 1-year extension (2006). Such conditions may include reduced dissolved oxygen (DO) levels, reduced food supply, physical disturbance, and consequent avoidance of habitat and increased energy expenditure and likelihood of predation. NMFS anticipates that up to 1,562 acres of the Delta may be treated with herbicides to control the *Egeria densa* infestation in any given year if all sites are treated to their maximal extent. This amounts to 2.5 percent of the water surface area in the Delta. This is unlikely given the past performance and limitations of the EDCP due to logistical constraints and the numbers and availability of application crews.

The total incidental take associated with this project is as follows:

ESU/DPS	Juveniles Number	Juveniles Percent of ESU/DPS	Adults Number	Adults Percent of ESU/DPS
Sacramento River winter-run Chinook salmon	462	0.14	1	0.01
Central Valley spring-run Chinook salmon	2057	0.14	1	<0.01
Central Valley steelhead	300	0.16	1	0.05

B. Effect of the Take

In the accompanying biological opinion, NMFS determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

C. Reasonable and Prudent Measures

NMFS believes that the following reasonable and prudent measures are necessary and appropriate to minimize take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead resulting from implementation of the action. These reasonable and prudent measures would also minimize adverse effects on designated critical habitat:

1. Measures shall be taken to reduce impacts to listed salmonids and their habitat from chemical control treatment and/or monitoring activities.

2. Measures shall be taken to reduce the impact of DBW's EDCP boating operations on listed salmonids and their habitat.

3. Measures shall be taken to monitor the DBW's *Egeria densa* control operations and the ambient Delta hydrologic conditions.

D. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, the USDA-ARS must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline the required reporting/monitoring requirements to be delivered to NMFS. These terms and conditions are non-discretionary.

1. **Measures shall be taken to reduce impacts to listed salmonids and their habitat from chemical control treatment and/or monitoring activities.**

    A. Chemical controls for the EDCP in the Delta shall not be applied before April 1, 2006, in any portion of the action area. Application of project herbicides will cease by October 15, 2006. Applications of herbicides may be conducted in areas of the Delta as follows:

1. The following sites may be treated after April 1 of each application season. Treated sections should start at the inner margin of the infested water body and move progressively outwards towards the main channels:

    a. White Slough, east of Honker Cut;
    b. Disappointment Slough, east of Honker Cut;
    c. 14 Mile Slough, 0.5 miles upstream of the San Joaquin River;
    d. Seven Mile Slough, 0.5 miles upstream of confluences with the San Joaquin River and Three Mile Slough;
    e. Pixley Slough
    f. Bishop/ Telephone Cut
    g. Franks Tract
    h. Sandmound Slough
    i. Rhode Island
    j. Little Potato Slough-Grindstone

2. The following sites can be treated as of April 15 of each application season:

    a. Old River at Del's after the temporary barriers are in place;
    b. Paradise Cut after the temporary barriers are in place

3. Chemical controls for the EDCP in the rest of the Delta may be applied after June 1 if technical guidance on real-time juvenile migration provided by Interagency Ecological Program (IEP) Real-Time Monitoring (found on the internet at: http://www.delta.dfg.ca.gov/) and verbal verification from NMFS, indicates that outmigration has concluded for the season for listed salmonids. Dependent upon the type of water year and in-stream flows, juvenile steelhead may be present in the Delta through May, and winter-run and spring-run Chinook salmon may be present in the Delta through June. Avoiding herbicide applications under these conditions will benefit listed salmonids.

4. The EDCP may operate from July 1 through October 15 without restriction to locations treated throughout the project area; chemical controls for the EDCP shall not be applied after October 15 of each treatment season.

B. Any Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead mortalities found at or in the vicinity of a treatment site shall be collected, fork length measured and the body placed in a whirl-pak bag. The bag will be labeled with the time, date, location of capture, a description of the near-shore habitat type and water conditions, and then frozen. NMFS' Sacramento Area Office (see contact information below) shall be notified within 48 hours and a representative of NMFS will collect the specimen.

C. DBW staff and their assigned agents must follow all Federal and State laws applicable to the use of the herbicides and any adjuvants and apply them in a manner consistent with the product labeling, the National Pollution Discharge Elimination System (NPDES) General Permit, Proposed Action, and determinations from the California Department of Pesticide Regulation.

D. Fish passage shall not be blocked within treatment areas. Protocols described in the project description shall be followed to ensure that EDCP operations do not inhibit passage of fish in each area scheduled for treatment or exceed limitations on contiguous treated acreage.

E. The DBW will provide a copy of each week's Notice of Intent (NOI) to NMFS' Sacramento Area Office (see contact information in 3(D) below) by the Friday prior to the treatment week. This notification will include the sites scheduled for treatment and a contact person for those sites.

F. A NMFS representative will be established on the *Egeria densa* Task Force and provide technical assistance to the Task Force, along with carrying out the duties of a Task Force member. As part of the Task Force, the NMFS representative will be active in guiding decisions on prioritizing treatment sites in regards to the presence of salmonids.

2. **Measures shall be taken to reduce the impact of DBW's EDCP boating operations on listed salmonids and their habitat.**

A. USDA-ARS and DBW shall comply with the receiving water limitations of the NPDES General Permit issued for the EDCP in regards to oils, greases, waxes, floating material, or suspended material derived from the operation of program vessels or application activities.

B. The USDA-ARS and DBW shall ensure that any mixing of chemicals, or disinfecting and cleaning of any equipment, shall be done in strict accordance with the operational protocols of the EDCP and that all equipment is in working order prior to engaging in application activities, including the operation of the program's vessels.

C. Operation of program vessels in shallow water habitats shall be done in a manner that causes the least amount of disturbance to the habitat. Operational procedures for vessels in these habitats shall minimize boat wakes and prop wash.

D. Operation of program vessels shall avoid or minimize to the greatest practicable extent dislodging portions of existing *Egeria densa* beds that can drift into other areas. This avoids creating new infestations of the weed due to drifting fragments.

3. Measures shall be taken to monitor the DBW's *Egeria densa* control operations and the ambient Delta hydrologic conditions.

A. The USDA-ARS shall ensure that the DBW follows a comprehensive monitoring plan designed to collect project operational information. The monitoring plan shall adhere to the requirements of the NPDES General Permit and have at a minimum those water quality criteria stated in Attachment B of the permit, *i.e.*, data on water temperatures, dissolved oxygen, pH, turbidity, water hardness, electrical conductivity, and chemical concentrations in the application areas, as well as other criteria stated in the attachment. Determinations of chemical concentrations shall have at a minimum, pre- and post-application water samples taken at the furthest down current site of the application zone.

B. The USDA-ARS, in coordination with the DBW, shall provide monitoring reports of the hydrologic conditions and the amounts of chemical discharges every other month to NMFS Sacramento Area Office (see contact information in 3(D) below). These reports shall also include information on the following parameters:

1. Pre-treatment and post-treatment measurements on chemical residues, pH and turbidity levels, as well as water temperatures and dissolved oxygen concentrations from pre-selected sites in the Delta. These sites shall be reflective of the different water types found in the range of application sites and will be determined by DBW as part of their NPDES General Permit conditions.

2. Receiving water temperatures and dissolved oxygen levels and resultant changes in those conditions resulting from EDCP operations.

3. Amounts, types, and dates of application of herbicides applied at each site.

4. Visual assessment of pre- and post-treatment conditions of treated sites to determine the efficacy of treatment and any effects of chemical drift on downstream habitats immediately adjacent to the treated sites.

5. Operational status of equipment and vessels, including repairs and spraying equipment calibrations as needed.

C. The USDA-ARS, in coordination with the DBW, shall summarize the above monthly reports into an annual report of the DBW project operations, monitoring measurements, and Delta hydrological conditions for the previous treatment year for submission to NMFS by January 31 of each year. The annual report of DBW operations shall also include:

1. A description of the total number of winter-run and spring-run Chinook salmon or steelhead observed taken, the manner of the take, and the dates and locations of the take, the condition of the winter-run Chinook salmon, spring-run Chinook salmon, or steelhead trout taken, the disposition of fish taken in the event of mortality and a brief narrative of the circumstances surrounding the take of the fish. This report shall be sent to the address given below.

2. Listed salmonids or other fish species that are observed to be behaving in an erratic manner shall be reported (see Appendix A).

D. All notifications or reports shall be submitted by mail or Fax to:

Office Supervisor
NMFS
Sacramento Area Office
650 Capitol Mall, Suite 8-300
Sacramento, California 95814

Phone: (916) 930-3600
Fax: (916) 930-3629

X. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on a listed species or critical habitat or regarding the development of pertinent information.

1. The USDA-ARS and its agents should support and promote aquatic and riparian habitat restoration within the Delta region, and encourage its contractors to modify operation and maintenance procedures through the service's authorities so that those actions avoid or minimize negative impacts to salmon and steelhead.

2. The USDA-ARS and its agents should support anadromous salmonid monitoring programs throughout the Delta and Suisun Bay to improve the understanding of migration and habitat utilization by salmonids in this region.

In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

XI. REINITIATION OF CONSULTATION

This concludes consultation on the amendment to the 2003-2005 biological opinion on the actions outlined in the October 24, 2005, request for consultation received from the USDA-ARS. This biological opinion is valid for the EDCP described in the original BA and supplemental information received by NMFS since the issuance of that document. As provided for in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in any incidental take statement is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species that was not considered in the biological opinion, or (4) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

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Appendix A: Tables

TABLE 1: EDCP Application Sites

Site Number	Site Name	Acreage	Description	% Waterbody Surface Acreage Covered with Egeria	Approx. Depth of Egeria
1	Frank's Tract	158	Large, open, and shallow water body in the western Delta	26	7
2	Venice Cut	147	Narrow channel in central Delta, south of Venice Island,east of Empire Tract	17	8
3	Big Break	23	Large, open,and shallow water body in western delta, no flow through capacity	21	5
4	Sherman Island	23	Large, open, and shallow water body in the western Delta	25	4
5	Rock Slough	37	Heavily infested slough running from south end of Sandmound Slough to Old River, south of Holland Tract	34	6
6	White slough	129	Slough north of Empire Tract and King Isalnd, running from Little Potato Slough to Telephone Cut	31	6
7	Fisherman's Cut	21	Cut directly north of False River at western side of Frank's Tract to the San Joaquin River	21	8
8	Taylor Slough	13	Slough on west end of Frank's Tract, running around Bethal Island and south to Dutch Slough	9	8
9	Sandmound Slough	38	Slough on west side of Holland Tract from Quimby Island to Rock Slough	17	8
10	Pipers Slough	19	Slough on southwest corner of Frank's tract connecting to Sandmound Slough	12	8
11	Lathum Slough	104	Slough on west side of McDonald Island, off of Middle River, in central Delta	16	8
12	Disappointment Slough	76	Slough south of Empire Tract and King Island, running rfom Stockton Deep Water Channel to Pixley Slough	14	7
13	Old River Del's	23	Portion of Old River south of Clifton Court Forebay near Del's Boat Harbor	8	8
14	Old River Connection	37	Most northerly portion of Old River where it joins Connection Slough north of Bacon island	19	7
15	Middle River Bullfrog	57	Portion of mIddle River next to Bullfrog Landing, west of Lower Jones Tract and south of Mildred Island	19	6
16	Middle River Jones	38	Portion of Middle River west of Upper Jones Tract and south to Woodward Canal	19	4
17	14 Mile Slough	52	Slough east of Stockton Deep Water Channel on the north side of Lower Roberts Island beginning near Windmill Cove Marina	19	6
18	Middle River Victoria	20	Portion of Middle River between Woodward Canal and Union Point east of Victoria Island	14	8
19	Donlon Island	12	Heavily infested island on east side of Sherman Isalnd, bordering the San Joaquin River	50	8
20	Rhode Isalnd	88	Island on the northwest side of Bacon Island, bordering Holland tract alnog Old River	28	5
21	Big break Wetlands	55	Heavily infested area on westernmost side of Big Break	77	8
22	Big Break II	3	Heavily infested area on southwest corner of Big Break	32	8
23	Seven Mile Slough	23	Slough on western portion of treatment area, north of Webb Tract	7	4
24	Dutch Slough	63	Heavily traveled slough connecting Big Break to Sandmound Slough through Bethel Island	18	9
25	Little Potato Slough	30	Slough connecting Potato Slough with White's Slough at itersection of Venice Island and Empire Tract	11	6
26	Turner Empire Cut	17	Cut intersecting Latham Slough at Mildred Island with Stockton Deepwater Channel, north of Lower Jones Tract and Roberts Island	8	6
27	Little Venice Island	12	Small island bordered by Mandeville Island to west, Medford Island to east and Venice Cut to north	27	6
28	Coney Island	12	Island on east side of Clifton Court Forebay	24	6
29	Hog Island	12	Island east east of McDonald Isalnd, bordering the Stockton Deep Water Channel and Hog Cut	5	6
30	Pixley Slough	27	Slough on east side of Delta, south of Bishop Tract, beginning at Paradise Point Marina	12	8
31	Bacon Island	30	Areas around Bacon Island in central Delta	18	8
32	Paradise Cut	18	Cut on southern edge of Delta, south side of Stewart Tract intersecting Old River	10	8
33	Bishop Telephone Cut	7	Located on eastern edge of Delta, running along west side Bishop Tract and including Telephone Cut	7	8
34	Old River Orwood	90	Portion of Old River bordering Orwood Island	20	8
35	Potato Slough	48	Slough north of Venice Island between Stockton Deep Water Channel and Little Potato Slough	11	8

Table 4.
Monthly Occurrences of Dissolved Oxygen Depressions below the 5mg/L Criteria in the Stockton Deepwater Ship Channel (Rough and Ready Island DO monitoring site) Water Years 2000 to 2004

			Water Year			
Month	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**Monthly Sum**
September	0	26**	30**	16**	30**	102
October	0	0	7	0	4	11
November	0	0	12	0	3	15
December	6	4*	13	2	13	38
January	3	4	19	7	0	33
February	0	25	28	13	0	66
March	0	7	9	0	0	16
April	0	4	4	0	0	8
May	2*	0	2	4	0	8
Yearly Sum	11	70	124	42	50	**Total=297**

* = Suspect Data – potentially faulty DO meter readings

** = Wind driven and photosynthetic daily variations in DO level; very low night-time DO levels, high late afternoon levels

Table 5. Salmon and Steelhead monitoring programs in the Sacramento - San Joaquin River basins, and Suisun Marsh.

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	***Chinook salmon, Steelhead***	Sacramento River	Scale and otolith collection	Coleman National Hatchery, Sacramento River and tributaries	Scale and otolith microstructure analysis	Year-round	CDFG
		Sacramento River and San Joaquin River	Central Valley angler survey	Sacramento and San Joaquin rivers and tributaries downstream to Carquinez	In-river harvest	8 or 9 times per month, year-round	CDFG
		Sacramento River	Rotary screw trap	Upper Sacramento River at Balls Ferry and Deschutes Road Bridge	Juvenile emigration timing and abundance	Year round	CDFG
		Sacramento River	Rotary screw trap	Upper Sacramento River at RBDD	Juvenile emigration timing and abundance	Year round	FWS
		Sacramento River	Ladder counts	Upper Sacramento River at RBDD	Escapement estimates, population size	Variable, May - Jul	FWS
		Sacramento River	Beach seining	Sacramento River, Caldwell Park to Delta	Spatial and temporal distribution	Bi-weekly or monthly, year-round	FWS
		Sacramento River	Beach seining, snorkel survey, habitat mapping	Upper Sacramento River from Battle Creek to Caldwell Park	Evaluate rearing habitat	Random, year-round	CDFG
		Sacramento River	Rotary screw trap	Lower Sacramento River at Knight's Landing	Juvenile emigration and post-spawner adult steelhead migration	Year-round	CDFG
		Sacramento-San Joaquin basin	Kodiak/Midwater trawling	Sacramento River at Sacramento, Chipps Island, San Joaquin River at Mossdale	Juvenile outmigration	Variable, year-round	FWS
		Sacramento-San Joaquin Delta	Kodiak trawling	Various locations in the Delta	Presence and movement of juvenile salmonids	Daily, Apr - Jun	IEP
		Sacramento-San Joaquin Delta	Kodiak trawling	Jersey Point	Mark and recapture studies on juvenile salmonids	Daily, Apr - Jun	Hanson Environmental Consultants

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	***Chinook salmon, Steelhead, Continued***	Sacramento-San Joaquin Delta	Salvage sampling	CVP and SWP south Delta pumps	Estimate salvage and loss of juvenile salmonids	Daily	USBR/CDFG
		Battle Creek	Rotary screw trap	Above and below Coleman Hatchery barrier	Juvenile emigration	Daily, year-round	FWS
		Battle Creek	Weir trap, carcass counts, snorkel/ kayak survey	Battle Creek	Escapement, migration patterns, demographics	Variable, year-round	FWS
		Clear Creek	Rotary screw trap	Lower Clear Creek	Juvenile emigration	Daily, mid Dec- Jun	FWS
		Feather River	Rotary screw trap, Beach seining, Snorkel survey	Feather River	Juvenile emigration and rearing, population estimates	Daily, Dec - Jun	DWR
		Yuba River	Rotary screw trap	lower Yuba River	Life history evaluation, juvenile abundance, timing of emergence and migration, health index	Daily, Oct - Jun	CDFG
		Feather River	Ladder at hatchery	FRH	Survival and spawning success of hatchery fish (spring-run Chinook salmon), determine wild vs. hatchery adults (steelhead)	Variable, Apr - Jun	DWR, CDFG
		Mokelumne River	Habitat typing	Lower Mokelumne River between Camanche Dam and Cosumnes River confluence	Habitat use evaluation as part of limiting factors analysis	Various, when river conditions allow	EBMUD
		Mokelumne River	Redd surveys	Lower Mokelumne River between Camanche Dam and Hwy 26 bridge	Escapement estimate	Twice monthly, Oct 1- Jan 1	EBMUD
		Mokelumne River	Rotary screw trap, mark/recapture	Mokelumne River, below Woodbridge Dam	Juvenile emigration and survival	Daily, Dec- Jul	EBMUD
		Mokelumne River	Angler survey	Lower Mokelumne River below Camanche Dam to Lake Lodi	In-river harvest rates	Various, year-round	EBMUD

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	***Chinook salmon, Steelhead, Continued***	Mokelumne River	Beach seining, electrofishing	Lower Mokelumne	Distribution and habitat use	Various locations at various times throughout the year	EBMUD
		Mokelumne River	Video monitoring	Woodbridge Dam	Adult migration timing, population estimates	Daily, Aug - Mar	EBMUD
		Calaveras River	Adult weir, snorkel survey, electrofishing	Lower Calaveras River	Population estimate, migration timing, emigration timing	Variable, year-round	Fishery Foundation
		Stanislaus River	Rotary screw trap	lower Stanislaus River at Oakdale and Caswell State Park	Juvenile outmigration	Daily, Jan - Jun, dependent on flow	S.P. Cramer
		San Joaquin River basin	Fyke nets, snorkel surveys, hook and line survey, beach seining, electrofishing	Stanislaus, Tuolumne, Merced, and mainstem San Joaquin rivers	Presence and distribution, habitat use, and abundance	Variable, Mar- Jul	CDFG
	Central Valley Steelhead	Sacramento River	Angler Survey	RBDD to Redding	In-river harvest	Random Days, Jul 15 - Mar 15	CDFG
		Battle Creek	Hatchery counts	CNFH	Returns to hatchery	Daily, Jul 1 - Mar 31	FWS
		Clear Creek	Snorkel survey, redd counts	Clear Creek	Juvenile and spawning adult habitat use	Variable, dependent on river conditions	FWS
		Mill Creek, Antelope Creek, Beegum Creek	Spawning survey - snorkel and foot	Upper Mill, Antelope, and Beegum Creeks	Spawning habitat availability and use	Random days when conditions allow, Feb - Apr	CDFG
		Mill Creek, Deer Creek, Antelope Creek	Physical habitat survey	Upper Mill, Deer, and Antelope Creeks	Physical habitat conditions	Variable	USFS
		Dry Creek	Rotary screw trap	Miner and Secret Ravine's confluence	Downstream movement of emigrating juveniles and post-spawner adults	Daily, Nov- Apr	CDFG
		Dry Creek	Habitat survey, snorkel survey, PIT tagging study	Dry Creek, Miner and Secret Ravine's	Habitat availability and use	Variable	CDFG

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
<u>*Central Valley*</u>	***Central Valley Steelhead Continued***	Battle Creek	Otolith analysis	CNFH	Determine anadromy or freshwater residency of fish returning to hatchery	Variable, dependent on return timing	FWS
		Feather River	Hatchery coded wire tagging	FRH	Return rate, straying rate, and survival	Daily, Jul - Apr	DWR
		Feather River	Snorkel survey	Feather River	Escapement estimates	Monthly, Mar to Aug (upper river), once annually (entire river)	DWR
		Yuba River	Adult trap	lower Yuba River	Life history, run composition, origin, age determination	Year-round	Jones and Stokes
		American River	Rotary screw trap	Lower American River, Watt Ave. Bridge	Juvenile emigration	Daily, Oct- Jun	CDFG
		American River	Beach seine, snorkel survey, electrofishing	American River, Nimbus Dam to Paradise Beach	Emergence timing, juvenile habitat use, population estimates	Variable	CDFG
		American River	Redd surveys	American River, Nimbus Dam to Paradise Beach	Escapement estimates	Once, Feb - Mar	CDFG, BOR
		Mokelumne River	Electrofishing, gastric lavage	Lower Mokelumne River	Diet analysis as part of limiting factor analysis	Variable	EBMUD
		Mokelumne River	Electrofishing, hatchery returns	Lower Mokelumne River, Mokelumne River hatchery	O. Mykiss genetic analysis to compare hatchery returning steelhead to residents	Variable	EBMUD
		Calaveras River	Rotary screw trap, pit tagging, beach seining, electrofishing	lower Calaveras River	Population estimate, migration patterns, life history	Variable, year-round	S.P. Cramer
		San Joaquin River basin	Fyke nets, snorkel survey, hook and line survey, beach seining, electrofishing, fish traps/weirs	Stanislaus, Tuolumne, Merced, and mainstem San Joaquin rivers	Presence, origin, distribution, habitat use, migration timing, and abundance	Variable, Jun - Apr	CDFG
		Merced River	Rotary screw trap	Lower Merced River	Juvenile oumigration	Variable, Jan-Jun	Natural Resource Scientists, Inc.

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	***Central Valley Steelhead Continued***	Central Valley-wide	Carcass survey, hook and line survey, electrofishing, traps, nets	Upper Sacramento, Yuba, Mokelumne, Calaveras, Tuolumne, Feather, Cosumnes, and Stanislaus Rivers, and Mill, Deer, Battle, and Clear Creeks	Occurrence and distribution of *O. Mykiss*	Variable, year-round	CDFG
		Central Valley - wide	Scale and otolith sampling	Coleman NFH, Feather, Nimbus, Mokelumne River hatcheries	Stock identification, juvenile residence time, adult age structure, hatchery contribution	Variable upon availability	CDFG
		Central Valley - wide	Hatchery marking	All Central Valley Hatcheries	Hatchery contribution	Variable	FWS, CDFG
	Sacramento River Winter-run Chinook salmon	Sacramento River	Aerial redd counts	Keswick Dam to Princeton	Number and proportion of reds above and below RBDD	Weekly, May 1- July 15	CDFG
		Sacramento River	Carcass survey	Keswick Dam to RBDD	In-river spawning escapement	Weekly, Apr 15- Aug 15	FWS, CDFG
		Battle Creek	Hatchery marking	Colemen National Fish Hatchery	Hatchery contribution	Variable	FWS, CDFG
		Sacramento River	Ladder counts	RBDD	Run-size above RBDD	Daily, Mar 30- Jun 30	FWS
		Pacific Ocean	Ocean Harvest	California ports south of Point Arena	Ocean landings	May 1- Sept 30 (commercial), Feb 15 - Nov 15 (sport)	CDFG
	Central Valley Spring-run Chinook salmon	Mill, Deer, Antelope, Cottonwood, Butte, Big Chico Creeks	Rotary screw trap, snorkel survey, electrofishing, beach seining	upper Mill, Deer, Antelope, Cottonwood, Butte, and Big Chico creeks	Life history assessment, presence, adult escapement estimates	Variable, year-round	CDFG
		Feather River	Fyke trapping, angling, radio tagging	Feather River	Adult migration and holding behavior	Variable, Apr-June	DWR
		Yuba River	Fish trap	lower Yuba River, Daguerre Point Dam	Timing and duration of migration, population estimate	Daily, Jan - Dec	CDFG
Suisun Marsh	***Chinook salmon***	Suisun Marsh	Otter trawling, beach seining	Suisun Marsh	Relative population estimates and habitat use	Monthly, year-round	UC Davis

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		Suisun Marsh	Gill netting	Suisun Marsh Salinity Control Gates	Fish passage	Variable, Jun - Dec	CDFG

Appendix B: Figures

Enclosure 2.

Magnuson-Stevens Fishery Conservation and Management Act (MSA)

ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended (U.C. 180 *et seq.*), requires that Essential Fish Habitat (EFH) be identified and described in federal fishery management plans (FMPs). Federal action agencies must consult with the National Marine Fisheries Service (NOAA Fisheries) on any activity which they fund, permit, or carry out that may adversely affect EFH. NOAA Fisheries is required to provide EFH conservation and enhancement recommendations to the federal action agencies.

EFH is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purposes of interpreting the definition of EFH, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary' means habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle. The proposed project site is within the region identified as Essential Fish Habitat (EFH) for Pacific salmon in Amendment 14 of the Pacific Salmon Fishery Management Plan and for starry flounder (*Platicthys stellatus*) and English sole (*Pleuronectes vetulus*) in Amendment 11 to the Pacific Coast Groundfish Fishery Management Plan.

The Pacific Fishery Management Council (PFMC) has identified and described EFH, Adverse Impacts and Recommended Conservation Measures for salmon in Amendment 14 to the Pacific Coast Salmon Plan (Salmon Plan) (PFMC 1999). Freshwater EFH for Pacific salmon in the Central Valley includes waters currently or historically accessible to salmon within the Central Valley ecosystem as described in Myers *et al.* (1998), and includes the San Joaquin Delta hydrologic unit (*i.e.*, number 18040003). Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), and Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) are species managed under the Salmon Plan that occur in the San Joaquin Delta.

Factors limiting salmon populations in the Delta include periodic reversed flows due to high water exports (drawing juveniles into large diversion pumps), loss of fish into unscreened agricultural diversion, predation by introduced species, and reduction in the quality and quantity of rearing habitat due to channelization, pollution, rip-rapping, etc. (Kondolf *et al.*, 1996a, 1996b; Dettman *et al.* 1987; California Advisory Committee on Salmon and Steelhead Trout 1998).

LIFE HISTORY AND HABITAT REQUIREMENTS

Pacific Salmon:

General life history information for Central Valley Chinook salmon is summarized below. Information on Sacramento River winter-run and Central Valley spring-run Chinook salmon life histories is summarized in the preceding Biological Opinion for the proposed project (Enclosure 1). Further detailed information on Chinook salmon ESUs are available in the NOAA Fisheries status review of Chinook salmon from Washington, Idaho, Oregon, and California (Myers *et al.* 1998), and the NOAA Fisheries proposed rule for listing several ESUs of Chinook salmon (NOAA Fisheries 1998).

Adult Central Valley fall-run Chinook salmon enter the Sacramento and San Joaquin Rivers from July through April and spawn from October through December (FWS 1998). Chinook salmon spawning generally occurs in clean loose gravel in swift, relatively shallow riffles or along the edges of fast runs (NOAA Fisheries 1997).

Egg incubation occurs from October through March (Reynolds *et al.* 1993). Shortly after emergence from their gravel nests, most fry disperse downstream towards the Delta and estuary (Kjelson *et al.* 1982). The remainder of fry hide in the gravel or station in calm, shallow waters with bank cover such as tree roots, logs, and submerged or overhead vegetation. These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Along the emigration route, submerged and overhead cover in the form of rocks, aquatic and riparian vegetation, logs, and undercut banks provide habitat for food organisms, shade, and protect juveniles and smolts from predation. These smolts generally spend a very short time in the Delta and estuary before entry into the ocean. Whether entering the Delta or estuary as fry or juveniles, Central Valley Chinook salmon depend on passage through the Sacramento-San Joaquin Delta for access to the ocean.

Starry Flounder:

The starry flounder is a flatfish found throughout the eastern Pacific Ocean, from the Santa Ynez River in California to the Bering and Chukchi Seas in Alaska, and eastwards to Bathurst inlet in Arctic Canada. Adults are found in marine waters to a depth of 375 meters. Spawning takes place during the fall and winter months in marine to polyhaline waters. The adults spawn in shallow coastal waters near river mouths and sloughs, and the juveniles are found almost exclusively in estuaries. The juveniles often migrate up freshwater rivers, but are estuarine dependent. Eggs are broadcast spawned, and the buoyant eggs drift with wind and tidal currents. Juveniles gradually settle to the bottom after undergoing metamorphosis from a pelagic larvae to a demersal juvenile by the end of April. Juveniles feed mainly on small crustaceans, barnacle larvae, cladocerans, clams and dipteran larvae. Juveniles are extremely dependent on the condition of the estuary for their health. Polluted estuaries and wetlands decrease the survival rate for juvenile starry flounder. Juvenile starry flounder also have a tendency to accumulate many of the contaminants in the environment.

English Sole:

The English sole is a flatfish found from Mexico to Alaska. It is the most abundant flatfish in Puget Sound, Washington and is abundant in the San Francisco Bay estuary system. Adults are found in near-shore environments. English sole generally spawn during late fall to early spring at depths of 50 to 70 meters over soft mud bottoms. Eggs are initially buoyant, then begin to sink just prior to hatching. Incubation may last only a couple of days to a week depending on temperature. Newly hatched larvae are bilaterally symmetrical and float near the surface. Wind and tidal currents carry the larvae into bays and estuaries where the larvae undergo metamorphosis into the demersal juvenile. The young depend heavily on the intertidal areas, estuaries and shallow near shore waters for food and shelter. Juvenile English sole feed on small crustaceans such as copepods, amphipods, and on polychaete worms. Polluted estuaries and wetlands decrease the survival rate for juvenile English soles. The juveniles also have a tendency to accumulate many of the contaminants found in their environment which may result in tumors, sores, and reproductive failures.

II. PROPOSED ACTION

The proposed action is described in section II (*Description of the Proposed Action)* of the preceding Biological Opinion for endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, Central Valley steelhead and critical habitat for winter-run Chinook salmon (Enclosure 1).

III. EFFECTS OF THE PROJECT ACTION

The effects of the proposed action on Sacramento River winter-run and Central Valley spring-run Chinook salmon habitat are described at length in section V (*Effects of the Action*) of the preceding biological opinion, and generally are expected to apply to Central Valley fall-run Chinook salmon, starry flounder, and English sole EFH. Effects on starry flounder EFH may be greater than those for English sole EFH due to the greater usage of freshwater habitat by juvenile starry flounder during the herbicide application period.

IV. CONCLUSION

Based on the best available information, NOAA Fisheries believes that the proposed *Egeria densa* Control Program (EDCP) may adversely affect EFH for Central Valley fall-/late fall-run Chinook salmon, Sacramento River winter-run Chinook salmon, and Central Valley spring-run

Chinook salmon managed under the Salmon plan. Likewise, the EDCP may adversely affect EFH for starry flounder and English sole in the action area.

V. EFH CONSERVATION RECOMMENDATIONS

The habitat requirements for Central Valley fall-/late fall-run Chinook salmon within the action area are similar to those of the Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead addressed in the preceding Biological Opinion (Enclosure 1). Therefore, NOAA Fisheries recommends that the terms and conditions 1a-b, 1d-e, and 2a-d from the biological opinion be adopted as EFH Conservation Recommendations for EFH in the action area. In addition, other conservation measures may be implemented in the project area, as addressed in Appendix A of Amendment 14 to the Pacific Coast Salmon Plan (PFMC 1999) where applicable to the authority of the USDA-ARS and the DBW. Starry flounder and English sole EFH may be protected by following the conservation recommendations for Pacific salmon EFH in addition to the following recommendations:

1. Minimize the application of herbicides in waters that serve as rearing habitat for juvenile flatfish in the Delta,

2. Minimize the disturbance of benthic substrate in areas of shallow water used by flatfish for foraging; and

3. Avoid degradation of native emergent and submerged vegetation in marshes and submerged tidal flats in areas utilized by juvenile flatfish for rearing and foraging.

VI. STATUTORY REQUIREMENTS

Section 305 (b) 4(B) of the MSA requires that the federal lead agency provide NOAA Fisheries with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the lead agency for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR § 600.920[j]). In the case of a response that is inconsistent with our recommendations, the USDA-ARS must explain its reasons for not following the recommendations, including the scientific justification for any disagreement with NOAA Fisheries over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

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